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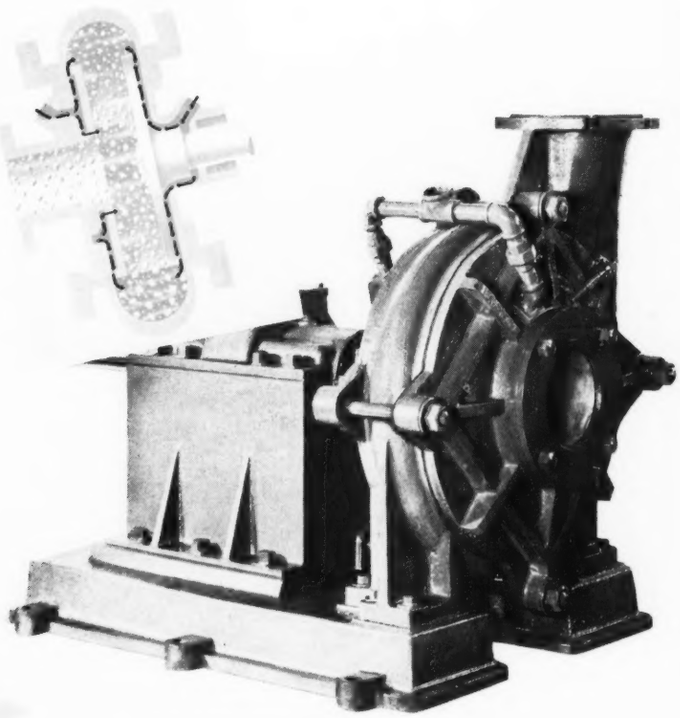

CANADA Allen-Sherman-Hoff, Ltd., Room 1103 350 Bay St., Toronto 2, Ont. U.S.A. The Allen-Sherman-Hoff Co. 2295 S. 15th St., Philadelphia, Pa. ENGLAND The Ash Co. (London), Ltd. 63 Lincoln Inn Fields, London, W.C.2

Engineering and Mining Journal March, 1934. Vol. 135. No. 3—Published monthly by the McGraw-Hill Publishing Company, Inc., 330 West 42d St., New York City, N. Y., U. S. A. Subscription rates, United States $3 per annum; Canada and other countries in the Americas outside the United States $4 per annum; elsewhere $5 or 20 shillings per annum. Price per copy, 50 cents or 2s. Entered as second-class matter June 20, 1879, at the Post Office, New York, N. Y., under the act of March 3, 1879. Printed in U. S. A.

Printed by The Schweinler Press, N. Y.

Engineering and Mining Journal

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McGRAW-HILL PUBLISHING COMPANY, INC.
330 West 42d St., New York, N. Y.
Cable Address: McGrawhill, N. Y.
Chicago: 520 North Michigan Avenue
San Francisco: 883 Mission Street
Montreal: 1188 Phillips Place

McGRAW-HILL PUBLISHING COMPANY, LTD.
Aldwych House, Aldwych,
London, W. C. 2, England
Cable Address: Backlash, Estrand, London

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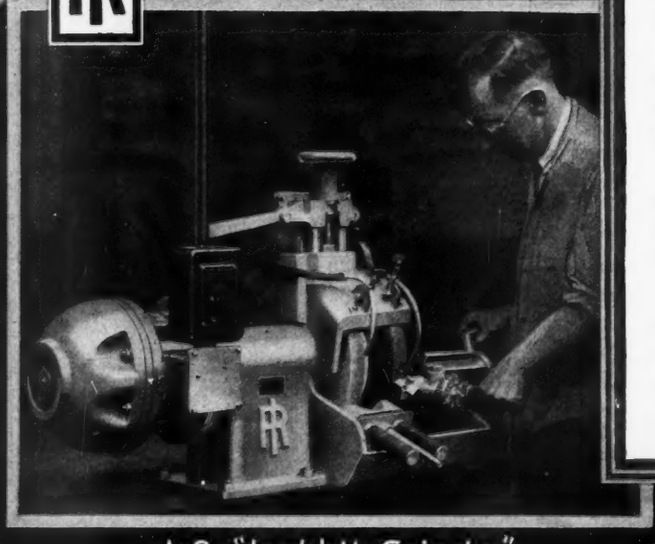

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MARCH, 1934 VOL. 135—No. 3

The Acid Test for Nineteen Thirty-four

OUT OF THE APPARENT CONFUSION and contradictions of the vast program for business recovery, one fact is evident to proponents and critics alike—namely, that current conditions and future prospects for returning prosperity are more hopeful today than at any time in the past three or four years. Not that the horizon is without warning clouds of storms that may yet break, but that the major indexes of industrial and trade activity have at last turned definitely upward.

Just as in 1933 the forces of recovery were concentrated on prices and monetary matters, so in 1934 emphasis will be placed on volume—volume of production, employment, trade, and capital investment. Such improvement as has been experienced thus far may be ascribed in large part to governmental spending through the various agencies that have been set up. But this social spending cannot continue indefinitely at the rate of ten to twelve billions of dollars a year. It has been undertaken in an effort to prime the pump of industry and trade in the hope and belief that the normal processes of private enterprise can be revived.

The acid test, then, for 1934 will be the vitality shown by business in relieving the Government of its unnatural load. Relief must come quickly, for already the termination of some governmental spending has been decreed. In effect, therefore, this year will witness a race on the part of business and industry to absorb the unemployed now dependent on the Government, at least as fast as they are dropped from public payrolls. Summer will be the critical season, at which time there may be a slight recession unless the normal processes of production and employment continue to improve.

In spite of the socialistic attitude of the Administration, as expressed in many of its reform measures, we have reason to believe that it still retains its faith in the private initiative and enterprise of a capitalistic economy. To revive that economy free from abuses and unfair practices will be the aim of Government and business alike in 1934.

Geophysical Prospecting And "Doodle Bugs"

OPERATORS of those contraptions known as "doodle bugs," for which surprising powers in finding minerals and treasure are claimed, always make secrecy and mystery a part of their procedure. Their concealment of the particular device they use or of their method of employing it is a necessary safeguard, and at the same time helps by increasing their importance in the eyes of unintelligent folk, who cannot distinguish them from upright and learned geophysicists. The ignorant person sees no difference between a magnetometer and a divining rod. For him, all is shrouded in the mystery of "science."

How different this secretive conduct is from the openness which has characterized the work of mining engineer, metallurgist, and geologist! Frankness in the exchange of information and readiness to impart full facts have been characteristic of those who have contributed most to the achievement of the profession. Secrecy, on the other hand, impedes progress and with it enters doubt. Especially should those engaged in geophysical prospecting avoid anything thus tainted. They will do well to bear in mind that they have their imitators, who lack their good intentions. Anything in common with the latter, such as the advertising of the possession of some effective method or instrument at the same time that they refuse to disclose its nature, is likely to prove a drawback in the end.

Pressure of Base-Metal Stocks Affects Price Levels

NUMEROUS COMMENTATORS on the major non-ferrous metal industries have repeatedly pointed out the fact that stocks of these metals exert, at any time, an important influence on

the prices that the metals command. By plotting a curve of prices and one for stocks, both on the same sheet, this contention may be readily substantiated for each of these metals. In this connection reference may well be made here to an interesting method of plotting such curves that Mr. Alex Skelton employs in his contribution on control in the base-metal industries which appears in "Elements of a National Mineral Policy," prepared by The Mineral Inquiry. Parallelism of movement of the price curve with the stocks curve is obtained by placing both the price and tonnage scales along the ordinate and reversing them with respect to each other, the time period scale being placed along the abscissa.

Existing United States stocks of copper, lead, and zinc severely handicap the respective industries, and efforts leading to their reduction would certainly seem desirable. For this reason the additions made to the stocks of all three of the metals in January cannot but occasion some concern. At the end of that month stocks of refined lead totaled 207,674 tons—a new high level; zinc stocks stood at 111,982 tons—after a steady increase month by month for five months; and an addition of 5,500 tons was made to the stocks of refined copper during the month.

Undoubtedly the higher prices for gold and newly mined silver are encouraging an increase in the output of complex ores containing the base metals, but the only method of coping with metal from this source would seem to be by curtailing output to a compensating extent at another source pending an improvement in metal consumption. Experience leads to the conclusion that until the current upward trend in base-metal stocks is arrested, little improvement in the price structure of the respective metals may be expected.

With the Institute In New York

ONE'S APPRAISAL of a convention is likely to be influenced by factors quite outside the program. Age and experience, the frequency of attendance in the past, the acquaintances present, all play a part. Youth tends to be enthusiastic, experience deepens appreciation or the lack of it, and the old-timer may long since have become blasé. One feature—the rendezvous of friends and of those having a common interest—ought to make the occasion pleasurable for almost everyone. To see a convention in all its excellence, the seasoned visitor should recall his earlier impressions and free himself from prejudices arising from familiarity. Any gathering of the sort holds inspiration to be won by those who seek it.

So with the recent annual meeting of the American Institute of Mining and Metallurgical Engineers. Those who approached it in a proper mood surely found it enjoyable and profitable. The technical program had its highlights; in particular one unusual feature—the sessions on mineral dust hazards or, more popularly, silicosis. Under the able chairman, Mr. B. F. Tillson, the important aspects of the problems offered by these risks to life and health were discussed authoritatively, and later an open forum was conducted. At this session, Mr. J. W. Barker, dean of the Engineering Schools at Columbia University and associate chairman, announced that Columbia will establish a council for research in silicosis that will act not only to integrate and coordinate the work now being done at various places and by various bodies and to direct attention to the gaps in research, but will also serve as fiscal agent in making grants in aid of research from funds to be supplied by industry and other sources.

Of unusual interest also were the sessions on nonferrous metallurgy and aërial transportation, the latter marked by a memorable paper by Mr. H. M. Wolflin, dealing exhaustively with the use of airplanes in mining work. This contribution will suffice as a textbook on the subject for some time to come.

Currency Stabilization and Gold Output Records

PRESIDENT ROOSEVELT'S ACTION in revaluing the dollar on January 31, thereby fixing the price of gold at $35 an ounce, is undoubtedly the first step among the nations of the world toward effecting an international stabilization of currencies. Much, of course, remains to be accomplished before that goal is finally achieved. From the standpoint of the gold-mining industry, however, this initial action is significant. Already indications prevail that the two leading gold-producing countries—South Africa and Canada—will resume in 1934 the steady growth in their annual output of the metal that continued for more than a decade prior to 1933. True it is that, owing to the higher price for gold, the total value of the metal produced by each of these two countries was greater last year than ever before, but this higher valuation is not as indicative of the actual status of the industry as is the slight recession in production that was recorded.

The tendency for the more important gold mines in the two aforesaid countries to keep output at a moderate rate last year is probably attributable to several factors, chief of which was the inescapable conclusion as the months passed that the price of the metal would in the near future advance further rather than decline. Such prospects do not encourage immediate increases in ore extraction. Perhaps the second most influential factor in the situation was that by mining low-grade ore at a normal tonnage rate operating forces were maintained and no loss in revenue was incurred, owing to the successive advances in the price of the metal during the year. Certainly, too, this policy of moderation would be well suited to discouraging the levying of further taxation on the industry.

As the goal of international stabilization of currencies approaches step by step, a return to the previous more "balanced" condition of the gold-mining industry may be expected. The prevailing higher price for the metal is a most effective incentive in stimulating the search for new properties, but as costs move up, as they must under devalued currencies, much of the existing profit margin that the gold miner enjoys will disappear. *Tempus fugit.*

An Engineer Revisits KALGOORLIE

Personal Observations on Current Conditions and Practice

M. W. von Bernewitz

Consulting Engineer

AFTER a long absence it is good to return to a place where you once worked harmoniously, to find it busy and improved, and to be welcomed by friends and engineers, and by acquaintances on the street. This is what recently happened to me at Kalgoorlie, Western Australia, after my being 21 years in the United States. Of course, many friends have retired, passed on, or moved away; but of such changes I had known through my continuous contact with the place. Yet Kalgoorlie [properly Kalgurli, aboriginal (not "bushman," as commonly termed by Americans) meaning "resort of dingoes" (wild dog)] has had its poor days, but it is now making the best of the unbalanced situation whereby gold sells at nearly double its par value. Few there are who will concede that the price will ever return to 85s. ($20.67) an ounce. In general, current opinion is that it will be pegged at a higher value. Anyhow, even if the world market for gold returns to £5 ($24), Australian producers are sure for several years of a price of £5 5s. ($26.67), owing to a bonus guaranteed by the Commonwealth Government.

Kalgoorlie has been a sort of savior to Australia: In 1893, when gold was discovered there by Patrick Hannan, it relieved the stress following the Eastern Australian bank failures and the burst land boom; in 1930-33, the period of intense depression, it came to the rescue again, by giving employment to many people and by producing much gold. Kalgoorlie and other centers made Western Australia, and Kalgoorlie has contributed 55 per cent of the total gold output of the State. The field has a total yield of $449,000,000 and has paid $115,000,000 in dividends.

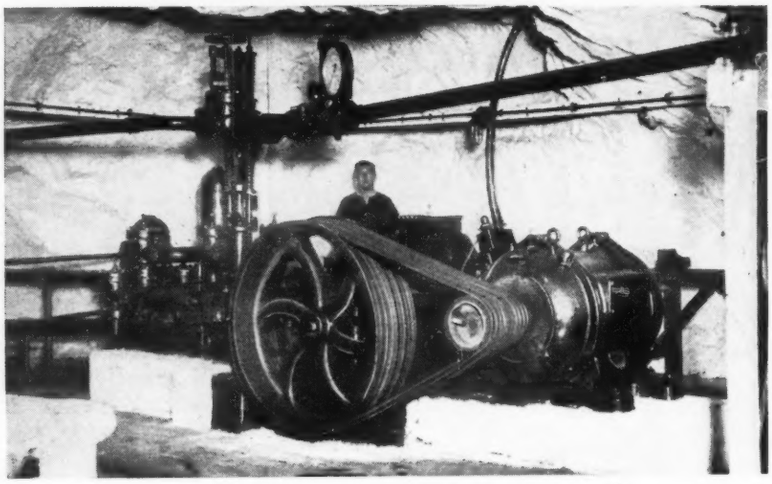
Drinking fountain in memory of Patrick Hannan. The water, piped 353 miles, flows from the spout of the water bag

The Golden Mile

When I left Kalgoorlie in mid-1912, twelve mines were producing and twelve mills were treating 140,000 tons a month, averaging about $8 per ton. Dividends that year totaled $3,100,000. Five thousand men were employed on the field known as East Coolgardie. In mid-1933, seven mines were producing and six mills were treating 80,000 tons of $8.40 ore a month. Dividends (exclusive of capital returned) totaled $960,000 in 1932 and $2,250,000 in 1933. Four thousand men are at work. But between these two periods came the World War and high commodity prices. Mines were shut down, the production curve sagged to a low point, pessimism held most persons, and the end seemed to be near.

Chronologically, we may say that the causes of the revival were the good ore production by many tributers, which more or less stirred the companies to action, this prior to 1928; the consolidation in that year of 520 acres by the Lake View & Star, comprising its own property and the properties of five others; extensive development by that company and by others; granting in 1930 of a $4.85 bonus an ounce on gold by the Commonwealth Government (later reduced to $2.40 and then canceled until gold returns to $24, when a price of $26.67 becomes operative); starting of the new mill of the Lake View & Star in 1930 and gradually bringing its daily capacity to 1,500 tons in 1933; starting of the Perseverance mill of 270 tons' capacity; the free market and high price for gold in 1933, which started further development and the building of a new mill at the Great Boulder; and new capital coming into the field and the State. The effect of large production from Wiluna was also a factor in revival.

Where Patrick Hannan first found gold at Hannan's, later renamed Kalgoorlie. The tree is a species of pepper



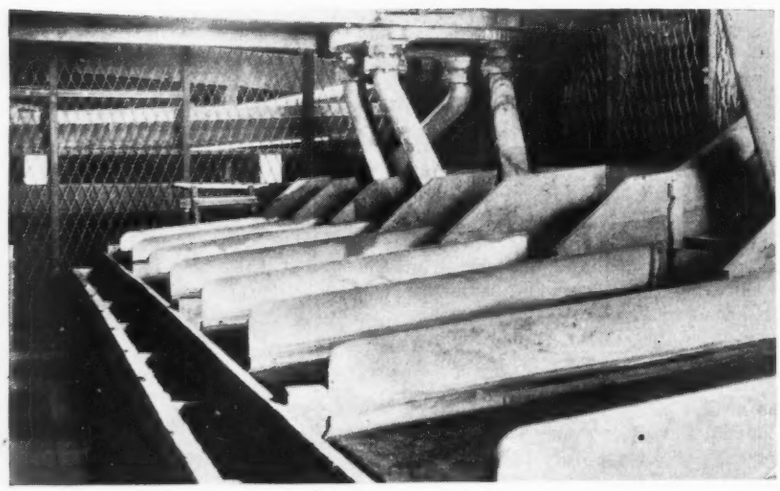
Three-throw pump in Boulder Perseverance mine at depth of 1,750 ft., which drains several properties. Capacity is 4,200 gal. per hour; diameter of plungers, 4 in.; and stroke, 10 in. Water is salty, containing 6 per cent solids

With regard to property changes, North Kalgurli absorbed Kalgurli, Oroya, Eclipse, Croesus Proprietary, and others; South Kalgurli took in the Hainault; and Lake View & Star corraled the Ivanhoe, Horsehoe, Chaffers, Hannan Star, and Boulder Main Reef. The Associated, Great Boulder, and Perseverance remain as formerly. North Kalgurli United is a new-comer, and the Enterprise leases are under option to the Broken Hill Proprietary, which has the Hannans North, about three miles north of the belt.

On each of the former producing mines absorbed are the remains of treatment plants—on the Oroya Links, Hainault, Kalgurli, Ivanhoe, and Horseshoe; also on the Lake View, always part of the Lake View & Star, and on the Associated Northern, recently sold to outsiders. These old plants are a source of scrap metals and some useful parts.

Recent development, to a depth of 3,600 ft., has exposed ore totaling three to four million tons, half of which is in the Lake View & Star group. Considerable drilling and other exploration are under way and contemplated. Stoping methods are flat-back and rill with filling, shrinkage, underhand, and sublevel. All drilling, excepting in one mine, is done wet. Lake View & Star has oil-fired furnaces for heating drill steel, and the machines sharpen about 2,000 drills a day. Tempering is done in mine salt water. The drills are distributed to the group of mines on flat four-wheel trailers hauled by a motor truck.

Corduroy tables in Perseverance plant. Rotary distributors provide an even, wave-like feed. Note the steel netting enclosure



Ventilation is natural along the Golden Mile. The average volume for each mine exceeds 50,000 cu.ft. per minute. Air distribution is by means of bratticing. Development ends are ventilated by Venturi blowers, which are quite satisfactory. Air jets of $\frac{3}{8}$ in. with 80 lb. pressure will induce 600 cu.ft. per minute of free air, impinging at the working face 500 ft. distant. The Chief Mine Inspector and an assistant have done good work on determination of dust in the mines and certain surface operations. The former showed me the Kotze konimeter, also used on the Rand, which he has visited, and the method of counting the dust particles on the slide under a Zeiss microscope. As many as twenty working faces can be visited and sampled in a shift. All dust counts exceeding 250 particles per cubic centimeter are considered high, 600 are dangerous, and 200 are fair for underground air. Kalgoorlie ore contains 20 per cent free silica, whereas other districts run to 33 to 80 per cent. Since 1926 the average number of particles in Western Australian mines has decreased from 370 to about 150 or less at the present time.

Tributers have been a factor in this district, particularly during the doubtful years. They have produced, as at Cripple Creek, in Colorado, a large quantity of gold. As many as 600 men were employed by tribute parties, and now there are about 200 in 60 parties. A State law enacted in 1932 gives tributers and companies equal share in the proceeds, the former paying all their own expenses—in effect, the split-check system. In 1930 the Eastern Goldfields Tributers' Association was formed, with a regular and active secretary.

The general purpose of the clinic operated at Picher, Okla., in the study of silicosis is well known in the United States. Kalgoorlie has a clinic operated by the Commonwealth Government and supported in part by the State Government. This health laboratory has a staff of six and is in close contact with the Chief Inspector of Mines. In 1921 the Federal Department of Health established a Division of Industrial Hygiene, which founded laboratories in important country centers of Australia. That at Kalgoorlie commenced work in 1925. It is housed in a double-roofed building standing about 3 ft. from the ground, and is therefore cool and suitable for the historical, physical, and X-ray examination of men who apply for employment, or those who have to be re-examined.

Three State statutes provide the authority to do this and to pay one-third of the compensation fund. The men and companies pay the balance of one-third each. The laboratory is well equipped with X-ray apparatus and detached dark room for developing films, a brick storage house for films, and a card index in the office. To date, nearly 14,000 original examinations have been made, and original and re-examinations exceed 4,000 a year. Many field studies are also made. A worker who is prohibited from accepting employment or who ceases to work because of lung trouble receives $3,600 at the rate of $16.80 per week; then, if he has continued to contribute to the fund, he gets $6 a week and $1.25 a child; or he may get half the ruling wage plus $1.80 a child until $3,600 has been expended; then, if he has contributed to the fund, $6 a week and $1.25 a child.

Metallurgy

Formerly, seven dry-crushing and roasting plants and five wet-crushing and concentrating or bromocyaniding plants were operated. Now, three dry plants and three wet plants are in operation. One of the former is being replaced by a wet plant. One of the present wet plants is three miles distant from the Golden Mile.

Excepting necessary upkeep and several improvements, the dry plants of the Associated, South Kalgurli, and Great Boulder crush in Krupp ball mills, roast in Edwards' and Merton furnaces, grind, agitate with cyanide, and filter. The South Kalgurli has put in the Merrill-Crowe precipitation system with considerable satisfaction. As far as the future is concerned—which means ore reserves—probably the Associated and South Kalgurli will retain their present treatment. It gives a high extraction of the gold, but with small tonnages (170 tons and 250 tons a day respectively) costs are fairly high. The Great Boulder is erecting a flotation plant to dispense with its 240-ton dry treatment mill. Only concentrate will be treated. Tributers' ore is not included in the foregoing tonnages.

Boulder Perseverance once had a large dry plant; now it has a compact wet plant run by five men, treating 270 tons a day. It is being enlarged to 400 tons to handle ore from the North Kalgurli mine also. The flowsheet is: jaw, gyratory, and Symons crushers; Hardinge mills crushing in cyanide solution and Dorr classifiers giving 95 per cent minus 150 mesh; corduroy to catch coarse gold; Dorr thickeners; spindle-and-arm agitators for pulp to which bromocyanide is added; Oliver filters; precipitation by the Merrill-Crowe system. Extraction is 92 per cent at low cost.

The Chaffers plant of Lake View & Star is treating 1,500 tons or more daily. The pyrite and telluride are floated and the remainder of the pulp is discarded. Gyratory and Symons crushers reduce the ore to ⅜ in.; Hardinge mills and tube mills with straight-line classifiers and bowl classifiers grind the ore to 95 per cent through 200 mesh; corduroy catches the gold; Dorr thickeners dewater the pulp; Fahrenwald and Minerals Separation flotation machines save the concentrate. Copper sulphate is added to the ball mills as a conditioner, also thiocarbanilide at the tube mills, and pine oil as a frother at the thickener underflow. Concentrate, which amounts to 7 per cent of the ore milled, is dewatered on Oliver filters, dried on a hearth, roasted in Edwards' furnaces, mixed with cyanide solution and lime, agitated, and filtered by an Oliver machine. Precipitation is by the Merrill-Crowe system. Extraction from the original ore is 92 per cent, at a cost of $1.60 per ton.

At the Hannan's North plant the process includes jaw crusher, ten stamps, corduroy strakes, tube mill, thickeners, agitators, and counter-current decantation. It treats 40 tons a day.

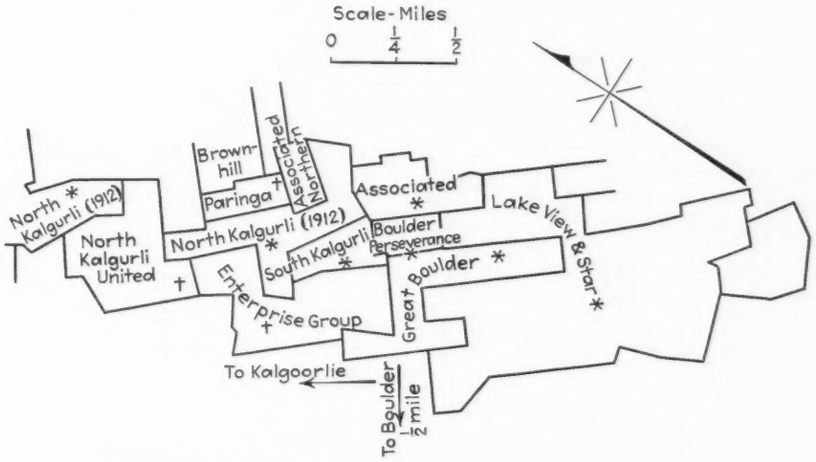
Although I did not visit the plant at Wiluna, I am told that the flowsheet resembles that of Lake View & Star. It handles 1,300 tons a day. As the pyrite contains arsenic, the fumes from the roasters are condensed to make white arsenic. This is done by an outside firm. Another flotation plant is being built at the old Lancefield mine, at Laverton, whose ore also carries arsenical pyrite.

The features of the new treatment are grinding mostly through 200 mesh; concentration by flotation, and discarding the remainder of the pulp; or grinding mostly through 150 mesh and bromocyaniding. Extraction appears to be similar and at much the same cost on a tonnage basis. But, of course, the cost is much lower than dry treatment.

Mention should be made of the diesel-engine power plant at the Lake View & Star mill, which generates electricity at 1.3c. per kilowatt-hour; the wood-fired assay and muffle furnaces at the same property, the former taking 70 crucibles at once and the other holding three muffles; general use of motors and the Texrope drive; the good work of Wilfley pumps; general satisfaction from the Merrill-Crowe precipitation system; the advantages of corduroy over copper plates—also the experience on the Rand; and the continued success of the roasting and cyaniding of concentrates.

Something should be said regarding several factors that have been of the greatest importance to Kalgoorlie—water, fuel, power, and transportation. Since 1903, the Goldfields Water Supply, a Government project, has been delivering good water through 30-in. pipe from a distance of 353 miles. Its capacity is 5,000,000 gal. a day, and the present consumption is 4,500,000 gal. Outside corrosion and inside pitting of the main conduit have been and are sources of expense, but this trouble has been stopped by lifting the pipes out of the trench, and by deaërating the water and substituting wood pipes or cement-lining the steel pipes. Since 1899, the West Australian Goldfields Firewood Supply Company has delivered more than 10,000,000 tons of firewood and mine timber. This is local growth of eucalypts, cut as far away as 136 miles. The company laid 1,800 miles of line at different times to tap the bush. Since 1902 the Kalgoorlie Electric Power & Lighting Corporation has been supplying part of their power to the mines. The installed capacity of turbines and reciprocating engines is 7,250 kw. The price is 3.2c. per kilowatt-hour.

Since 1917 the Trans-Australian Railway of the Commonwealth Government has been operating from the Eastern States to Kalgoorlie. This gives direct and quicker communication than by rail to the west coast and then east



Property boundary map, as of Jan. 1, 1934; *producing property, †exploration in progress. Quartz dolerite greenstone comprises bulk of area, with belt of uralitic quartz dolerite at the northern end and on southern side

by boat, and gives easier access to a long stretch of desert country. A quarry on the Nullabar Plains supplies Kalgoorlie with good and cheap lime. This plain is treeless and consists of limestone (largely cherty) for its entire length of more than 300 miles. In discussing transportation, the good work done by camels should not be forgotten.

The Town Itself

In 1912, Kalgoorlie, Boulder, and the Roads Board district had a population of 30,000. During the dull times the total was about 12,000. Now the two towns have 9,000 and 6,000 respectively, with an additional scattered population of 2,000 or 3,000. During the lean years the district was denuded of hundreds of houses, which were moved to the farms near the west coast and along the Trans-Australian line. Now, almost a house famine prevails; but many new homes of a better type than formerly are being built. These are either of full weatherboard or partly so with "Fibrolite" (a cement-asbestos sheet) and lined with this material. Doubtless the new zinc-coated, corrugated iron roofs will be painted white, as are the old ones. They are much cooler than the old type of house. Expenditures for erection of houses in Kalgoorlie in eighteen months totaled $250,000. Temperatures go high here, up to 110 deg. F. or more, and for days on end remain over 100 deg. in the shade; but it is a dry heat. Many "goldfielders" went on the land, and some did well for a while, but, as in other countries, too many were engaged at the same thing, and prices for products became too low. Many temporary farmers have returned to the mines.

Kalgoorlie shows much improvement of late—renovated houses, shops, fences, and street cars; new curbs, sidewalks, and paved streets; and a general air of prosperity. The municipality has always been carefully financed and solvent, and is able to make many improvements. Profits from the electric lighting plant help considerably.

Although dust storms, so common in some interior Australian towns, still annoy Kalgoorlie people, they have been lessened within the town by full and part paving of streets. Of course, a lot of dust comes from many miles distant. This is also true around the mines: whereas formerly mill residues were dumped by belt stackers, now they are pumped to dams which are built up as they fill. Some of them are splendid examples of the shoveler's art and appear to have been lined-up by surveyors. Thirty million or more tons are stacked on and around the Golden Mile. I call them the Pyramids of Kalgoorlie.

Other observations at Kalgoorlie include the great tree growth, particularly pepper, palm, and eucalypts, in spite of only 9 in. of rain and an evaporation of 87 in. per annum. A few fruit trees grow fairly well. Victoria Park, watered by waste from the municipal pool, is full of large trees and a remarkable growth of the creeper *bougainvillaea*, which also is common and luxuriant in gardens. Some men go to work by street cars, which now run infrequently; others by bicycles and motor cars. Trains formerly frequently encircled and ran through the whole district; now none run. Although more than 30 hotels ("pubs") were delicensed in the district, as many or more remain and a lot of beer is consumed. Little drunkenness, however, is visible. Only three of the hotels could be recommended for accommodation; the others are mainly drinking places. Septic tanks have improved hotels, some homes, and other places, and health officers watch sanitation generally and inspect the food that comes to Kalgoorlie.

Exploration

Along what is termed the Golden Mile and the area surrounding it—and also in adjacent and distant districts—many property changes are to be observed. Residue dumps are being treated, pegging (staking) of abandoned and new leases (claims) is going on, old mines are being reopened, and new gold discoveries made. A third of the nearly 1,000,000 square miles of Western Australia has possibilities. Prospectors, miners, tributers (lessees), geologists, and engineers are active.

Applications for miner's rights (license) to prospect and the right to work certain ground keep the Registrars and the Warden's Court busy hearing cases. State aid to mining includes its operation of stamp mills and cyanide plants, assistance and advice to 500 prospectors, mine inspection, and geologic studies and tests by the Kalgoorlie School of Mines, all adjuncts of the Department of Mines.

Company prospectuses and promotions are fairly frequent, and share speculation is active. The Chamber of Mines attends to factors that may affect the mining industry. All of this results in an increase in the State gold production, as it does in the other five Australian states. And—of importance to shareholders—dividends are being paid. Lake View & Star has resumed distributions after ten years; South Kalgurlie is paying off its capital as well as paying dividends.

Conquest of the Desert

In 1912, Kalgoorlie had only a few motor cars. I remember riding with the now Chief Mine Inspector in a so-called "horseless carriage"; also in an old Ford car of the Associated Northern Company. Now there are 1,000 motor cars and trucks and 200 motorcycles in Kalgoorlie and Boulder, the adjoining town. They are very useful about the district, but more so in going to other centers. The drive of 350 miles to the Wiluna mine is covered in one day, mainly over semi-desert roads. Prospectors and engineers drive everywhere to examine new or old areas and mines. Department of Mines inspectors travel in large trucks to visit and advise men receiving prospecting aid. Petrol (gasoline) costs 50 to 60c. per gallon.

Air-Mail Service

The conquest of the Australian desert is slowly but surely taking place by means of the motor car or truck, by airplane, and by railway. The last mentioned has opened about 1,500 miles of desert and semi-desert in each of the Western States and South Australia. Airplanes have flown from Alice Springs to the Granites field, in North Australia, and to other places in Central Australia, and the Mackay Aërial Expedition has explored part of Central Australia and along the Queensland border. The Western Mining Corporation has built a hangar at the Kalgoorlie airdrome, and will soon start its explorations over an area of 80,000 square miles by means of two airplanes, the "Gay Prospector" and the "Golden West." Air mail is transported once a week from Perth to the Eastern States and returned therefrom, much of the 2,500 miles or more each way being over desert and semi-desert. In Central and North Australia the motor car and truck have shown good performance. All the aids to transportation benefit the mining industry; but one important factor is frequently lacking away from the settled centers—namely, good water, although this may be found later; and the fly pest and heat exist. Wood for fuel is plentiful in many parts.

Acknowledgments

A tribute of appreciation to everyone who was so courteous to me during my visit to Kalgoorlie would require the mention of at least fifty names, so general thanks and acknowledgment are here offered, with especial reference to the following: W. Phoenix, Chief Inspector of Mines; J. M. Anderton, General Secretary, Chamber of Mines of Western Australia; Dr. K. R. Moore, in charge of the Commonwealth Government Health Laboratory; B. H. Moore, director, C. O. G. Larcombe, geologist, and W. G. Clarke, research metallurgist, in the School of Mines; Mr. Donnelly, editor of *The Kalgoorlie Miner*; H. E. Vail, vice-president, C. A. Thielecke, acting general manager, C. F. Bown, mill superintendent, and E. C. Rosman, accountant, Lake View & Star; F. G. Brinsden, manager, South Kalgurli; Duncan McAulay, manager, and W. B. Chomley, metallurgist, Associated; J. Warrick, manager, and A. Frazer, metallurgist, Great Boulder; C. E. Blackett, manager, Boulder Perseverance; W. Thomas, accountant, North Kalgurli (1912); Bain Hogg, mill superintendent, Hannan's North; W. R. P. Marmion, manager, The Kalgoorlie Electric Power & Lighting Corporation; M. V. Weatherall, consulting, engineer; and C. G. Elliott, secretary, Eastern Goldfields Tributers' Association.

A Cross-Section of the New York Meeting

Outstanding Papers of the Program

SOME OF THE HIGHLIGHTS of the technical program of the annual meeting of the American Institute of Mining and Metallurgical Engineers, held in New York, Feb. 19-22, are given in the following pages. The abstracts of the papers presented constitute an interesting cross-section of the proceedings. Like its predecessors, the meeting was well attended. In the news section (pages 128-35) will be found a brief account of the more important non-technical happenings that characterized this year's convention.

Service of Government Bureaus

Two Appraisals—Suggestions as to Policy

IN TWO PAPERS the work of geological surveys has been appraised from the viewpoint of the public and of mining geologists.

Broad public interest in the work of the surveys, state and national, must be recaptured if their service is to be supported by legislative appropriations, in the opinion of George W. Bain, instructor in geology in Amherst College. Even the unquestioned value of geological surveys to the mining industry will be heavily discounted and lost to sight unless popular approval is gained by other activities that arouse and sustain public interest. Lacking popular approval and support, the surveys will fall ready victims to the program of economy of legislators who are under pressure to cut the cost of work they cannot justify.

Three groups of people must be satisfied by the surveys: taxpayers, legislators, and scientists and teachers. The first group must receive, or be persuaded that they receive, some service in return for their taxes. The second must be able to justify their expenditures in the public interest. The third group, small in number but important in terms of benefits received, must publicize the work of the surveys and interpret their service to the public. This publicity can take the form of informational publications and contributions to the press, written in popular style but with scientific accuracy, and designed to convey geological information to taxpayers and legislators. Such popular treatises for the education of the majority would profitably supplement the strictly scientific and technical publications which, though of interest to only a few, are now overemphasized.

In analyzing the service of the surveys, Dr. Bain shows their relation to (1) producers of mineral products, (2) consumers, and (3) the general public. As an example of service to producers, he cites early geological work at Leadville which indicated that the oreshoots were in the blue limestone and were limited principally to that part of the limestone below the intrusive sheets of white, or alaskite, porphyry. This was a general observation of a regional characteristic that indicated which parts of the area merited exploration, and made possible a great saving in cost of developing the camp.

Typical of geological service that should be rendered to consumers of mineral products, particularly structural stone, is information for architects and construction companies regarding the durability and other properties of building stones. Some state surveys, according to Dr. Bain, are particularly backward in furnishing such information on their natural resources, resulting in improper selections and costly failures.

Service to the public can be extended in two forms: (1) information that can be used in making investments, and (2) readable descriptive literature on the geological features of an area that will attract the tourist and pleasure seeker. On the first point Dr. Bain observes that the larger the number of satisfied investors in the mineral industries, the greater will be the revenue for surveys and investigations in this field.

A Suggested Program For the U. S. Survey

COMMENDING the past work of the U. S. Geological Survey in its relation to metal mining, Reno H. Sales, chief geologist of the Anaconda Copper Mining Company, has outlined a constructive program for that organization appropriate to the changed needs of the mining industry. He has examined the work of the Survey in the light of its fundamental objectives stated by Walcott and Emmons; namely, "to accomplish for the mining industry, as a whole, what the individual mining engineer or mine owner cannot succeed by his unaided exertions in doing," and "to determine the general laws which govern the formation of ore deposits."

The Survey has done a good job in the past in the examination and study of mines and mining districts; but in

recent years it has drifted to the study of regions of new discoveries and partly developed areas. No criticism of the value of the latter work is made, but the problem is presented of maintaining a balance between scientific work on ore deposition on the one hand, and the more practical help in the development of mineral resources on the other. From the point of view of the mine geologist the scientific work is of the highest importance, and Mr. Sales believes the earlier Survey reports should be supplemented by reexaminations of known districts to keep pace with geological developments in the mines. Reference is made to the fact that no such reexamination was ever made of the Comstock and Eureka districts, in Nevada, following the elaborate reports of 1882 and 1884, notwithstanding the availability of a 'wealth of geological information of value to the student of ore deposition.

Study of well-developed districts would achieve four objectives: (1) progress in solving problems of ore deposition; (2) development of ore reserves in the district and of similar ore deposits elsewhere; (3) rejuvenation of abandoned districts; and (4) correction of previous errors in geological interpretation. A suggested program is offered to attain these objectives, enlisting the cooperation of mining company geologists to conserve time and effort.

Six criticisms of Survey work are made by Mr. Sales, and constructive suggestions are offered to meet them: (1) delay in examining new areas and in follow-up examinations; (2) delay in publication of results; (3) unsatisfactory distribution of publications; (4) too small editions of publications on important areas; (5) no re-issue of out-of-print reports and maps, and no separate issues of geological maps accompanying reports, and (6) overlapping of activities of national and state geological surveys.

In deploring the loss of mine and geological records of many abandoned properties, Mr. Sales suggests that the Government should require that owners, before abandonment, place such records and maps in the confidential files of the Survey for future use. Looking to the future of the mining industry, he thinks the work of the Survey as vital as ever, and urges generous support of its activities.

Service of Bureau of Mines To Non-Metallic Industry

WORK of the U. S. Bureau of Mines on non-metallics is designed to increase further the efficiency of recovery and to develop domestic production to replace imports, according to Dr. Scott Turner, Director. The Bureau has led in applying ore-dressing methods, including flotation and gravity concentration, to non-metallic ores. Its investigation of fine grinding will increase efficiency in the treatment of these ores and in the preparation of products such as cement and feldspar flour. The technologic work has been done largely in Rolla, Mo., and Tuscaloosa, Ala., the studies covering barite, bauxite, chromite, cyanite, ferberite, fluorspar, graphite, hubnerite, limestone, manganese oxides, phosphate, rhodochrosite, scheelite, siderite, and wolframite.

Investigations of chemical and physical properties of minerals have been the basis for improving methods for treating certain non-metallic ores. Recent examples include explosive-shattering, alternating-current magnetic separation, and electrostatic separation. A laboratory is maintained for chemical engineering and scientific research on non-metallic minerals.

The economic services of the Bureau to the non-metallic industries are as diversified as their field. Far from being largely statistical, the routine statistical canvasses conducted by the Bureau are supervised by engineers familiar with both the producing and the consuming branches. Supplementing the work on individual commodities, groups of products have recently been considered to develop basic economic data. Thousands of special inquiries regarding non-metals are annually answered by the Bureau. First-aid training has been given to about 3,000 persons in the quarrying, cement, and non-metallic mining industries. Safety records in these industries are annually assembled and analyzed by Bureau field men. Safety statistics on quarries and non-metallic mines are published annually, and on these much of the safety work in these industries is predicated. The Bureau, moreover, has investigated health conditions in these industries and has issued many publications regarding them.

Lead-Softening Plant Drosses

Removal of Impurities Contained in Base Bullion

COMPOUNDS present in dross, matte, and speiss produced in lead softening are lead sulphide, cuprous sulphide, solid solution of cuprous sulphide and ferrous sulphide, copper arsenides (Cu_5As_2 plus Cu or As), and metallic lead and copper, according to C. M. Dice and T. B. Brighton, research assistant and research metallurgist, respectively, University of Utah, and G. L. Oldright, supervising engineer of the Intermountain Experiment Station, U. S. Bureau of Mines. Other compounds not positively identified may be iron arsenide and copper antimonide. Metallic copper in the matte probably results from the reaction between copper sulphide and iron sulphide, to form "moss copper." In iron-free mattes no metallic copper is found.

Much lead is retained by cuprous sulphide or by lead sulphide. Sulphide mixtures, such as cuprous sulphide plus lead sulphide or iron sulphide, do not retain as much metallic lead as do the pure sulphides. The main part of the metallic lead retained by the matte-speiss products is suspended in copper arsenides, chiefly in Cu_5As_2. This lead content is at a minimum when the ratio of copper to arsenic is 3.5:1; for greater or smaller ratios lead content increases.

Obviously, the impurities in the blast-furnace charge should be kept as low as economy permits and should be removed as early as possible in the metallurgical flowsheet. The first opportunity is in the concentration process, where much of the copper or arsenic may be taken out. Arsenic is also readily volatilized in the roasting operation. Indications are that hearth furnaces give more effective removal than Dwight-Lloyd machines. More rapid volatilization is also obtained with reduction agents such as coal, sulphur, or pyrites in the charge.

An open, porous blast-furnace charge likewise aids in expelling arsenic. The type of furnace atmosphere conducive to most rapid volatilization depends on the compounds of arsenic present. Little arsenic is likely to volatilize after metallic lead is being freely liquated. Iron and sulphur assist in the reduction; the former replaces lead in the sulphide and forms a speiss with arsenic, thus keeping this impurity out of the bullion. Too much iron in a basic slag may combine with sulphur and arsenic to the point where copper goes into the bullion.

Speiss may be returned to a roasting furnace of the hearth type for removal of arsenic. Use of a drossing reverberatory was developed as an improvement over concentration of copper in matte by roasting and resmelting. The quantity of lead retained in the sulphides of the matte-speiss from one smelter was about the same with no iron and with 10 per cent metallic iron. Addition of metallic iron to various synthetic mixtures, beyond a certain point, did not result in further reduction in the content of metallic lead. Heating above 1,000 deg. C. for two hours or more, or settling for a longer period than one hour, did not aid in removing lead. The cleanest separation is obtained by slow solidification with separation of the various layers, rather than by granulation of molten speiss or matte.

Flash Roasting

Experimenters Seek Wider Application of the Process

DESIRE to determine the possibility of applying flash roasting in the metallurgy of copper has been the main objective of experiments conducted at the Bureau of Mines Southwest Experiment Station, according to Frank S. Wartman, assistant metallurgist of the Bureau. This work has been done on a laboratory scale, in a roasting chamber made from insulated sillimanite, a tube 6 ft. high and 2 in. in diameter. Tests have been made with chalcopyrite and chalcocite. The results have shown that almost complete roasting of these two minerals can be obtained experimentally in the sizes usually found in flotation concentrates with a high percentage of sulphur dioxide in the gas. In the range 1,000 to 1,100 deg. C., variation in particle size below 100 mesh has no significant effect on the sulphur content of the calcine, using up-draft and some excess of air; with down-draft the sulphur content increases with the particle size. Variation in the temperature between 1,000 and 1,250 deg. C. has little effect, but a temperature much below 1,000 deg. C. gives a calcine much higher in sulphur, and below 700 deg. C. very little roasting takes place. Up-draft gives more complete sulphur removal than down-draft; the excess sulphur in the latter case is usually in sulphate form. At temperatures above 1,000 deg. C., utilization of oxygen is almost complete up to the point where most of the sulphur is removed, and excess oxygen has little effect in reducing the sulphur in the calcine.

Tests have also been made to obtain information about copper ferrite in the calcine and the possibility of leaching the copper with the reagents commonly used. It has been found that formation of ferrite may be prevented by keeping the roasting temperature below 700 deg. C. and by using a very fine feed, but the grinding cost would be excessive and the operation difficult to carry out on a large scale. Therefore one may conclude that for the present, at least, calcines produced by flash roasting of iron-copper sulphides are not leachable.

At Copperhill experiments with flash roasting of iron concentrate were made in a seven-hearth, 22½-ft. Wedge furnace, with hearths 3 to 6 removed, and hearths 1 and 2 retained for dust collection and heat control under the drying hearth, according to George E. Beavers, in charge of research, Tennessee Copper Company. An iron concentrate, predominantly pyrrhotite, was used. With a moisture content not exceeding 9 per cent, 45 tons could be dried per 24 hr. From the drying hearth the concentrate passed by gravity through a surge bin onto a belt choke feeder dropping it directly into a 10-in. pipe through which it was blown into the furnace, just below the second hearth. The gas passed from the roaster by the regular outlet into a 30-in. Sirocco collector and then to the acid plant.

No trouble has been had in burning the fine-iron concentrate; in fact, the heat of the reaction was so great that a rate of 45 tons of concentrate per 24 hr. was the maximum permissible. The result indicates that the heat generated in roasting a concentrate with 38 per cent sulphur and 52 per cent iron necessitates special handling, for which reason the installation cost per ton of roaster feed may be too great to compete with hearth roasting. The interesting features may be thus summarized:

1. The sulphur dioxide content of the gas may be varied between wide limits. Eight per cent, with 1.3 per cent sulphur in the calcine, has been common practice, and 13 per cent has been obtained.

2. Temperatures of the exit gases are very high. Roasting 60 tons or more per 24 hr. in a modified Wedge roaster, the temperature may rise to 2,000 deg. F., with 0.2 per cent sulphur in the calcine. If the entire roaster system could be constructed to withstand such temperatures, ideal roasting conditions, in regard to output and sulphur elimination, would be attained.

Waste-Heat Boiler Practice

Essential Data From Seven Metallurgical Plants

A SYMPOSIUM on waste-heat boiler practice at copper metallurgical plants was on the program. According to E. S. Bardwell, superintendent of Anaconda's copper refineries, each of three refining furnaces at Great Falls has a waste-heat boiler: two have a Stirling A-30 400-hp. unit, and one has a 300-hp. A-21. None of

Table I—Rate of Steam Production

	With Oil Fuel, 400-Hp. Boiler	With Gas, 400-Hp. Boiler	With Gas, 300-Hp. Boiler
Charging	295	178	146
Melting	395	290	306
Skimming	...	310	283
Rabbling	288	298	134
Poling	368	573	630
Casting	260	441	282
Average	337	322	312

Table II—Average Boiler Test, 1928-29 and 1933
Anaconda Reverberatory Plant

	1928–29	1933
Date		
Location	Reverbs.	Reverbs.
Make of boiler	Stirling	Stirling
Average boiler rating, hp.	750	600
Character of firing	Pulverized coal	Natural gas
Coal as fired, tons per 24 hr.	80.28	(Gas, 2,472,000 cu.ft.)
Equivalent evaporation from and at 212°F. per 24 hr. lb.	593,034	749,267
Average steam-pressure gage, lb.	138.4	124.5
Average feed-water temperature, deg. F.	80.3	72.7
Horsepower developed	716.2	904.9
Horsepower, per cent of rating	95.5	150.8
Equivalent evaporation from and at 212°F. per pound coal as fired	3.694	.....
Equivalent evaporation from and at 212°F. per 1,000 cu.ft. gas burned	.....	303.10
Percentage of total heat of fuel absorbed by boiler. (Based on gross B.t.u.)	29.52	28.81
Average boiler inlet temperature, deg. F.	2101	2050
Average boiler exit temperature, deg. F.	857.9	810
B.t.u. in fuel as fired (gross)	12,140	(Gas, 1021 cu.ft.)
Percentage moisture in fuel as fired	3.10	.....
Reverberatory data. Hearth dimensions	23'4" × 134'6"	23'7" × 133'1"
Tons solid material smelted per furnace day	577.04	612.27
Tons solid material smelted per ton coal	7.19	.....

Table III—Steam Generation and Heat Recovery Data
Nevada Consolidated Copper Corporation

B.t.u. per pound coal as received	12,140
B.t.u. per pound coal as burned	12,460
Feed-water temperature, deg. F.	193
Feed-water temperature leaving economizers (when operating), deg. F.	310
Steam temperature, deg. F.	447
Superheat, deg. F.	63.9
Gage pressure, lb. per sq.in.	191
Absolute pressure, lb. per sq.in.	203
Total heat in steam, B.t.u. per lb.	1,237.9
Total heat in feed water, B.t.u. per lb.	161.0
Heat input to steam, B.t.u. per lb.	1,076.9

	Without Economizer Boilers 15 Days Operation in Jan., 1933	With Economizer Boilers 29.7 Days Operation in Feb. and March, 1933
Steam produced per pound coal as received, lb.	6.18	6.84
Steam from and at 212° per pound coal as received, lb.	6.91	7.65
Steam produced per pound coal as fired, lb.	6.33	7.02
Steam from and at 212° per pound coal as fired, lb.	7.08	7.85
Per cent recovered in steam of B.t.u. in coal as received	54.8	60.7
Per cent recovered in steam of B.t.u. in coal as burned	55.9	61.9

Table IV—Heat Balance of Waste-heat Boiler, Garfield Smelter

Item	B.t.u. per Cu.Ft.	Per Cent
Calorific value of fuel	876	100
Heat absorbed by boiler	262.5	29.98
Heat loss due to burning H_2 to H_2O	122.5	13.99
Heat loss due to heat in dry flue gas	147.8	16.88
Heat loss due to CO	.....	.....
Heat loss due to H_2O in air	1.0	0.11
Heat absorbed by furnace	333.8	38.08
Heat loss through radiation and unaccounted for between boiler inlet and outlet	8.4	0.96
	876	100.00
Available heat absorbed by boilers, per cent	.....	48.4
Steam pressure, lb. per sq. in. gage		153.6
Barometer, in. of mercury		25.6
Feed-water temperature, deg. F.		190
Flue-gas temperature before boiler, deg. F.		2,310
Flue-gas temperature after boiler, deg. F.		850
Volume of fuel per hour, cu.ft.		162,400
Weight of water evaporated per hour, lb.		45,650
Gas pressure at burners, lb. per sq.in. gage		15

Table V—Steam Production Data, United Verde Smelter

Pulverized coal as burned contained	11,520	B.t.u. per lb.
Heat input to steam	= 1,202.8	B.t.u. per lb.
Steam generated:		
Per pound pulverized coal actually burned	4.18	
Per pound pulverized coal from and at 212° F.	5.18	
Percentage recovered in steam of B.t.u. in coal actually burned	43.6	
SUMMARY:		
Tons solid charge smelted per 24 hr.		883
Tons pulverized coal (5.2 per cent H_2O) burned per 24 hr		112.58
British thermal units per ton solid charge		2,938,000
Pounds water evaporated per ton solid charge smelted		1,067
Pounds water evaporated per million B.t.u.		363
Efficiency based on pulverized coal actually burned at the furnace:		Per Cent
To smelting, conduction, convection, and radiation losses		43.0
Transferred to steam		43.6
Leaving in stack gases		13.4

Table VI—Essential Data, Miami Smelter

Furnace uptake temperature, deg. F.		2,300
Average boiler exit gas temperature, deg. F.		500–550
Feed-water temperature, deg. F.		168.4
Steam pressure gage, lb. per sq.in.		184.8
Steam pressure, abs., lb. per sq.in.		197.7
Steam temperature, deg. F.		413.1
Superheat, deg. F.		32.2
Total heat in steam, B.t.u.		1,218.5
Heat in feed water, B.t.u.		136.4
Heat input to steam, B.t.u.		1,082.1
Actual unit evaporation per pound oil burned, lb.		6.95
Equivalent unit evaporation (from and at 212° F.) per pound oil burned, lb.		7.75
Heat recovered in gross steam produced of heat in fuel burned, per cent		41.3
Heat input of fuel consumed per ton of charge smelted, B.t.u.		5,597,570
Water evaporated per ton of charge smelted, lb.		2,135
Water evaporated per million B.t.u. of heat input, lb.		382

Table VII—Steam Production, Magma Copper Company

Estimated heat value of oil, B.t.u. per lb.		18,500
Feed-water temperature, deg. F.		250
Steam temperature, deg. F.		500
Gage pressure, lb.		200
Total heat in steam, B.t.u. per lb.	1,265	
Total heat in feed water, B.t.u. per lb.	218	
Heat input to steam, B.t.u. per lb.	1,047	
Water fed to boilers per pound oil burned, lb.		6.30
Equivalent evaporation from and at 212°, lb.		6.80
Recovered in steam of B.t.u. in oil burned, per cent		35.6
Temperature of boiler exit gas, deg. F.		645

them are baffled. Fuel has been natural gas since 1928. Before that two had been fired at first with coal, later with oil; the third with oil. Rate of steam production during the furnace cycle is given in Table I.

Average temperature of gases entering the boilers is 1,940 deg. F. With oil as fuel, gas per hour going to the boilers was 1,875,200 cu.ft.; with gas as fuel, it was 2,140,258 cu.ft. Expressed in B.t.u. the respective figures are 15,572,950 and 17,954,509. Gases entering the stack averaged 4,261,681 and 6,627,921 B.t.u. per hour respectively, with oil and gas as fuel, leaving available for producing steam and caring for heat losses 11,311,265 B.t.u. per hour with oil and 11,326,588 with gas. Subtractinf 760,000 B.t.u. per hour for heat losses and dividing by 33,305 gives 317 boiler-horsepower, which is close to the test results given in Table I.

Anaconda's reverberatory plant has Stirling boilers for waste-heat utilization. Data supplied by E. A. Barnard and George Tryon on boiler tests covering two major operating periods are given in Table II. Boiler efficiencies based on fuel burned in reverbs remained nearly constant regardless of kind or amount of fuel burned.

All boilers at the waste-heat plant of Nevada Consolidated Copper Corporation are of the Stirling type, according to N. W. Skager and H. W. Mossman. Each of two reverberatories has its own set, and until recently delivered gases to its own boilers only. Last year the plan was adopted of using some of the boilers as economizers to operate in conjunction with those generating steam, and an advantageous gas-flow scheme was devised. Essential data pertaining to steam generation and heat recovery are given in Table III.

At the Garfield smelter, Utah, the waste-heat boiler plant has two 490-boiler-horsepower Erie City vertical water-tube boilers and six 330-boiler-horsepower, K19 Stirling water-tube waste-heat units, according to R. A. Marriott, plant engineer. Each furnace has its boilers in battery setting. All boilers act as single pass. From 3,000 to 3,500 thousand cubic feet of natural gas is burned per furnace per day at 15 to 20 lb. per square inch gas pressure. Gases enter the boiler at about 2,300 deg. F. and leave between 800 and 900 deg. F. Typical operating results are given in Table IV.

Two boilers serve each reverberatory at the smelter of the United Verde Copper Company, Clarkdale, Ariz. Each is of the M-26 Stirling type, rated 713 boiler horsepower. Steam production data, summarized for an eight months' period, as presented by J. R. Marston, metallurgist, are given in Table V.

Miami Copper, according to P. D. I. Honeyman and P. A. Faust, of Inspiration, Ariz., has only one of four 120-ft. reverbs in operation. It is oil-fired and is served by four 713-hp. M-26 Stirling boilers and two 850-hp. M-31 units. Fuel consumed, daily average, is 450 bbl. containing 6,205,732 B.t.u. per barrel. This is delivered to the furnace at 70 lb. and then heated to 190 to 200 deg. F. before burning. Essential data are given in Table VI.

At Magma Copper smelter, Superior, Ariz., according to J. H. Rose, the 96x22-ft. reverberatory has two Erie City 700-hp. vertical boilers, making steam at 200-lb. gage and a total temperature of 500 deg. F. from feed water at 250 deg. Fuel is heavy Bunker C fuel oil heated to 200 deg. F. and supplied at 100-lb. gage to six burners using air at slightly under 2-lb. gage pressure. Data on steam production are given in Table VII.

A Modern "Silver Refinery"

Produces Precious Metals, Selenium, Tellurium

EQUIPMENT and operations of the complete, up-to-date "secondaries" plant, or silver refinery, can be separated into six main divisions, according to C. A. Mosher, superintendent of the silver refinery at Anaconda's Raritan Copper Works, at Perth Amboy, N. J. These are:

(1) Slime treatment, in which operation the raw slime is treated by wet methods to remove its higher copper content and portions of other impurities such as arsenic, selenium, and tellurium. (2) Furnace refining, in which the rest of the base-metal content of the slime is removed by fluxing and fire-refining. (3) Electrolytic parting and refining, in which the silver and gold are parted and obtained in the pure state. (4) Melting of silver and gold into marketable form. (5) Recovery and refining of the more precious metals. (6) Re-

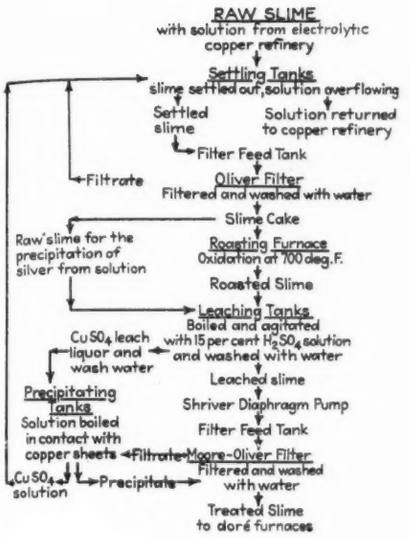


Fig. 1—Flowsheet of slime treatment in Raritan silver refinery

covery and refining of selenium and tellurium.

The Raritan refinery is of such a nature and in a general way is typical of other plants of its kind. Its processes are shown in the flowsheets in Figs. 1 to 3.

The selenium plant is capable of a production of 3,000 lb. of powdered selenium per month and the tellurium plant can turn out 1,500 lb. of metallic tellurium per month.

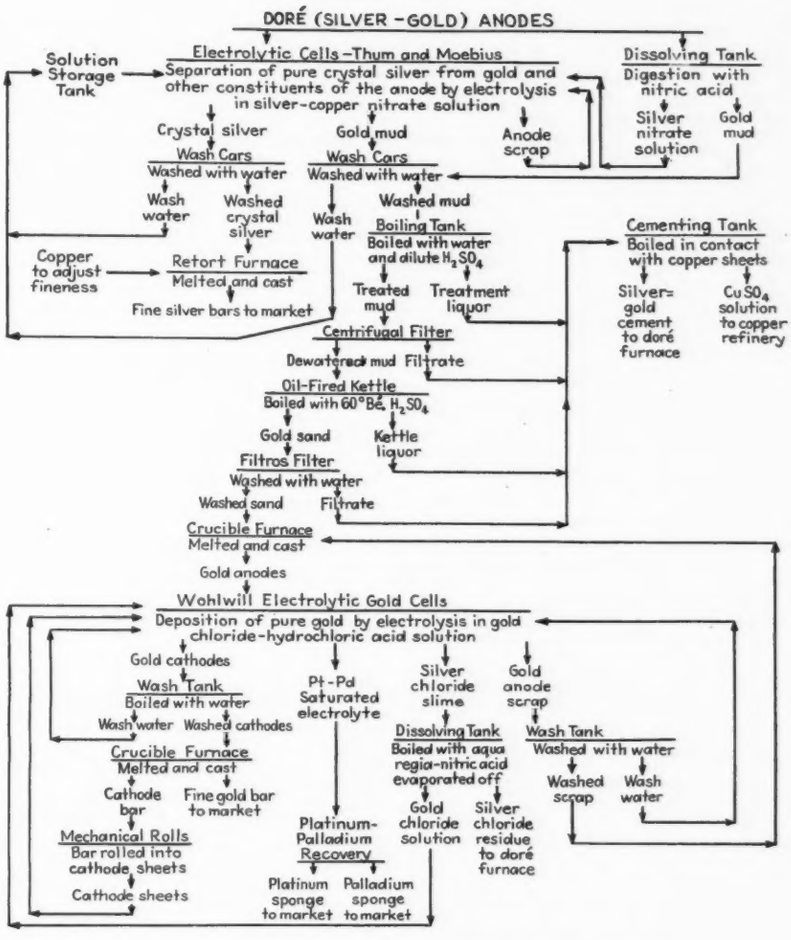
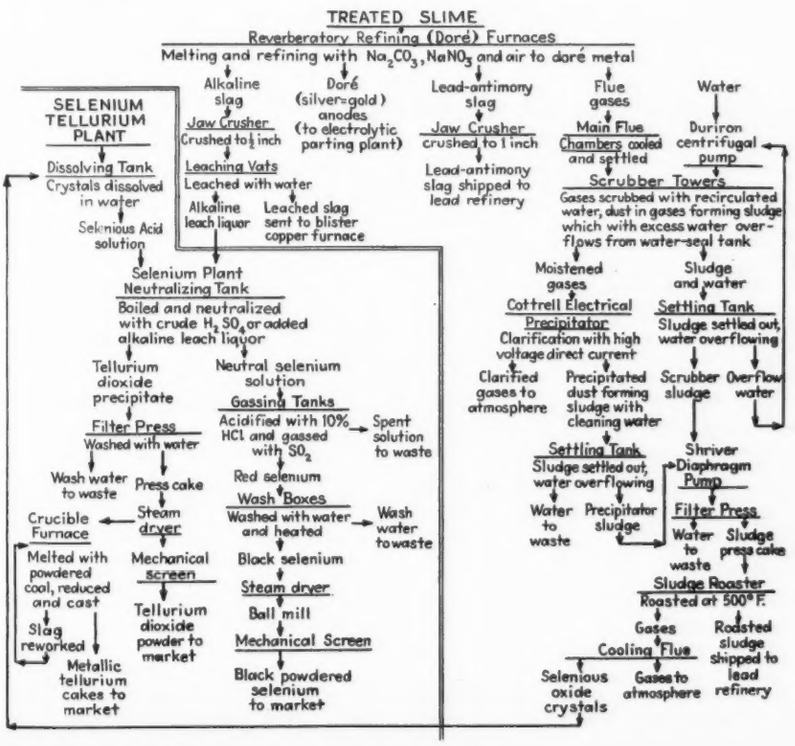


Fig. 3—Flowsheet of electrolytic parting and refining of precious metals in refinery of Raritan plant

Fig. 2—Flowsheet of furnace refining and selenium-tellurium recovery at Raritan silver refinery



Anodes From Converter Copper

IN 1930, when a refinery was built at Montreal East to refine the copper from Noranda and from Hudson Bay Mining & Smelting Company, Noranda decided to make its anodes at its plant, directly from the liquid converter copper, according to W. B. Boggs and J. N. Anderson, smelter superintendent and assistant smelter superintendent, respectively, of Noranda Mines, Ltd. A study of the different types of furnaces used for this purpose led to the selection of a reverberatory furnace with a Walker wheel. A furnace designed to hold 150 tons was built. At present, due to alterations, its capacity is 120 tons. Inside dimensions are 28 ft. 3 in. from bridge wall to the front end, and 11 ft. across at the widest point. Buckstays at 3- to 4-ft. intervals are held at top and bottom

with rods kept at constant tension with springs, a great advantage, as no adjustment of tie rods is needed during heating and cooling.

The Walker wheel, which is on the floor level and not in a pit, has an outside diameter of 33 ft. and has 22 molds, for 710-lb. anodes. Anodes are cast one at a time, with the wheel at rest, at an average rate of 93 anodes, or 32 tons of copper, per hour. Between 1 and 2 per cent is scrapped, mainly on account of wrong weight or defective Baltimore groove lugs. Present copper production is between 90 and 100 tons a day, which with a charge of 120 tons means casting six times a week. The molds were formerly made in cast-iron master molds, but they are now cast in sand, a method recently developed at a refinery in the United States. Firing is with pulverized coal, supplied by a Kennedy-Van Saun unit pulverizer. Coal consumption is about 90 lb. per ton of good anodes with present capacity; with full capacity a rate of 75 lb. may be obtained.

Several changes have been made in the original construction of the furnace. The arch is at present made of 20-in. silica brick, the flue of silica brick, and the verb of magnesite brick. But the most interesting change is the replacement of the original silica bottom with a basic monolithic bottom. After less than two months' operation, more than half of the original bottom came up; the remainder was then dug out, and a new bottom was made from Magnifrit, a basic refractory made from Quebec dolomite by Canadian Refractories, Ltd. In laying the new bottom this material was fused on a foundation of fireclay brick, at about 2,700 deg. F. A small quantity of an iron compound was added to the Magnifrit to reduce its fusion temperature and to aid in bonding. Twenty-four successive layers of this material, from $\frac{1}{2}$ to $\frac{3}{4}$ in. thick, were fused in, at average intervals of 4 hr. The mixture was thrown in with shovels through openings in the sides and front, as rapidly as possible to prevent undue cooling of the furnace, and each layer was sampled carefully before a new application was made. In all, 28 tons of Magnifrit was used, and the actual work of making the bottom required 108 hr. This bottom is still in good condition, after nearly three years' operation, with indication that it will last for many years. During the period of operation mentioned it has been patched four times, with nine days' shutdown. From March 19, 1931, to Nov. 1, 1933, over $31\frac{1}{2}$ months, 86,415 tons of copper has been taken out of the furnace.

Ball Milling

A New Philosophy Enters Its Study

CONCENTRATORS of the United States house about 650 ball, rod or pebble mills, operating or ready to operate, and these have about 100,000 connected horsepower, according to Alexander M. Gow, M. Guggenheim, A. B. Campbell, and Will H. Coghill. For grinding in cement plants about three times this connected horsepower is available, and other industries have an unestimated amount, all used for the general type of grinding here to be discussed. True, these figures do not represent stupendous amounts of power, but when one considers that ball milling is often the "bottle neck" in a concentrator, and that it often accounts for the largest single item in the cost sheet, the importance of a comprehensive understanding of the principles involved can be appreciated.

Much past literature has been concerned with the Kick-Rittinger dispute over evaluating grinding, or with dissertations on ball paths and the closely allied impact-versus-attrition hypotheses, or with the exclusive consideration of certain specific variables, such as mill speed or circulating load, irrespective of other operating factors. Such subjects may be dismissed with but little discussion in what may be called, by comparison, a new philosophy in the study of ball milling. Briefly, this "new philosophy" consists of using power as an index of the mill operation, and investigating grinding from the standpoint of set and induced variables, with emphasis on the latter.

Research by the four investigators has revealed certain underlying principles that have puzzled earlier experimentors. It has shown that a study of ball paths and trajectories cannot be expected to explain the power requirements or grinding capacity of a mill; that no set variable may be studied comprehensively without considering the associated induced variables; that impact and attrition differ only in amount and degree of grinding, not in type; that the percentage of over-all circulating load is not necessarily indicative of the amount of stage grinding and that useful circulating load data should be used to give a true analysis; that rationing of feed rate to ball action (power) and of ball size to grain size are necessary for good operation; that the proper ball size is independent of the hardness of the ores tested; and that the grinding may be made proportional to the power expended.

A power study has shown how variables, including slipping and the amount of ore in the mill, affect the power; and a method and formula are offered by the investigators whereby the power required by a cylindrical mill of any size and operating under any conditions may be estimated. This also makes possible correlation of the performance of various commercial mills. They also discuss the effects on power and grinding of the following: Size and design of mill; amount and size of ball charge; size, type, feed rate, and pulp density of feed; speed of rotation of the mill; efficiency of classification in closed circuit; slipping; and amount of material in the mill at any instant.

Oxygen-free Flotation

A Series of Investigations With Galena

THE great importance of the problem of oxidation to both the theory and practice of flotation led S. Frederick Ravitz and Robert R. Porter, research metallurgist and research fellow, respectively, at Engineering Experiment Station, Salt Lake City, Utah, to make a series of flotation investigations under oxygen-free conditions. Galena was chosen as the mineral for study because most of the evidence in support of the chemical theory of flotation has been obtained with it.

In most of the experiments made the mineral used was an exceptionally fine sample of galena from the Joplin district of Missouri. Analysis gave the following composition: Pb, 86.2 per cent; S, 13.2; Zn, 0.10; Fe, 0.10; insoluble, 0.00; Cu, 0.00. This galena had been crushed and sized about a year before these experiments were started and had been stored in closed bottles. Reagents employed were: crude commercial sodium ethyl xanthate purified by recrystallization from acetone; carefully redistilled "chemically pure" terpineol; and "chemically pure" ammonium acetate. An inert atmosphere was obtained with cylinder nitrogen, stated by the manufacturers to be 96.6 per cent pure.

As a result of their experiments the investigators reached the following conclusions:

1. Pure unoxidized galena will float completely and very rapidly with terpineol solution alone, even at very low concentrations.

2. Pure unoxidized galena will float completely and very rapidly with sodium ethyl xanthate solution alone.

3. Pure unoxidized galena can be floated in the complete absence of any reagents.

4. Presence of oxidation products on the surface of galena exerts an inhibiting effect on its flotation.

5. Surface-oxidation products are not essential for the flotation of galena with ethyl xanthate.

6. The idea frequently expressed, that air will not displace water from pure galena surfaces, is incorrect.

Centralized Ore Delivery

Real del Monte Finds Scheme Advantageous on Several Counts

MINES operated by the Compañia de Real del Monte y Pachuca, Pachuca, Mexico, as H. I. Altshuler pointed out, are in two districts, the Pachuca and Real del Monte. The principal area of mineralization is within a rectangle roughly 10 miles from east to west and 6 miles from north to south. It contains a number of veins from 2 to 20 ft. wide, which are exploited by this mining company. The scattered position of the producing mines led to the construction of two mills between 1906 and 1908; the Loreto mill, in Pachuca, averaged 2,600 tons daily, and the Guerrero mill, in Real del Monte, milled 1,270 tons daily. On Feb. 1, 1929, the management decided to enlarge the Loreto mill to take the combined tonnage of both mills at that time. This measure required the centralization of ore delivery, which would also afford a material saving in the cost of ore transport. The centralization would give the company the following advantages over the former system:

1. Beneficiation at a single mill, closer to source of materials and supplies than the abandoned Guerrero mill. The refinery is also in the Loreto patio.

2. Ore delivery to surface at one point (San Juan Pachuca shaft) instead of at four points.

3. Elimination of aërial tramways.

To achieve the results desired from centralization, two important underground changes were necessary. First, the ore from the Camelia group had to be taken through the San Juan Pachuca shaft, the demolition of the lower Loreto bins being necessary for the mill enlargement; second, the ore from Real del Monte had to be delivered by underground haulage to the San Juan Pachuca shaft. This latter step required: (*a*) a good haulage level from La Rica shaft in Real del Monte to the San Juan Pachuca shaft in Pachuca; (*b*) a haulage level in Real del Monte to deliver the ores to a central point near La Rica shaft; (*c*) bins at this central point, as well as at the San Juan Pachuca shaft; (*d*) hoisting and haulage equipment to assure economical and continuous ore delivery. Inasmuch as a good part of the ore handled comes from leased chains, provision of suitable bin capacity and control of ore delivery to keep the various ores separate were of prime importance.

Centralization was completed according to schedule and has given good working service from the start. The cost was heavy, even though all the expected benefits have been realized. The subsequent drastic decline in the price of silver could not have been foreseen, but has made the centralization of much greater value than any calculation of cost reduction would have indicated. Due to the price decline, the workable ore reserves in the Pachuca district have been greatly reduced and nearly all new discoveries of importance have been in Real del Monte.

In 1929, La Rica tramway was working to capacity. Had it not been for the centralization, giving flexibility of ore delivery, the Loreto mill would not have had sufficient ore for its demands, whereas the Guerrero mill would have been greatly oversupplied. The company is fortunate in having now a system of ore delivery which will allow the production schedule for each mine to follow the requirements of development and the management's desires.

Experimental Air-Conditioning

Process Devised for Anaconda's Mines Appears Practicable

MANY METHODS of air-conditioning have been considered by Anaconda Copper Mining Company, but not until recently, according to William B. Daly and A. S. Richardson, has a process been developed that seems economically practicable. Its essential feature is the circulation of calcium chloride brine in a closed circuit in which the brine is alternately heated by the warm air within the mine workings and cooled by the cold air of the surface atmosphere; it thus serves continuously to cool the warm mine air and to dissipate the heat at the surface. Main equipment items are:

1. A cooling tower at which the brine is cooled by the surface atmosphere. Temperatures as low as —20 deg. F. are not uncommon in winter, and the wet-bulb temperature seldom exceeds 60 deg. F. in summer.

2. Pipe lines to carry the brine in closed circuit. The hydrostatic head in the two lines being in balance, power is required only to overcome friction resistance, plus the small lift to the top of the tower.

3. Main brine circulation pump.

4. Mine air-conditioning plants. Brine from the main inlet circulates through high-pressure pipe coils, which complete the closed circuit to the return line. Water is pumped through sprays into the warm mine air and falls on to the pipe coils, thus transferring heat from the mine air to the brine. The spray water then falls into a sump, from which it is again pumped to the sprays, completing its own closed circuit. Circulation of brine through the pipe coils is in a direction opposite to the air flow.

The most important fact demonstrated by this experimental plant is that this air-conditioning method permits temperature and humidity of air in the working places to be controlled within limits not possible by ordinary ventilating methods. Tentatively, it is planned that, as an average mine condition, the temperature of the air shall not exceed 75 deg. F. with a relative humidity of 75 per cent, and the realization of such a standard seems entirely practicable.

As to the elimination of dust from mine air, the results are thought better than those obtainable by present methods, such as water blasting, but the drying of the working places by the dehumidification of the air naturally tends to increase dustiness, and an extension of the practice of wetting down working places will probably be necessary.

Operation of the plant disclosed the fact that a design providing for considerable variation in capacity will be desirable. When such a plant is first put into operation the area to be ventilated may be small, but soon the ventilation of a much larger area may be necessary. Still later, when most of the ore in that section of the mine has been removed, a smaller quantity of conditioned air may again be sufficient. This flexibility in capacity affects not only the air-conditioning equipment itself but also the selection of suitable fans.

The major item of expense is the cost of the main circuit pipe lines, which will naturally vary considerably at different mines. Assuming that new shafts were to be sunk, crosscuts made to the different veins, and a fan installed, in accordance with present practice, the initial expense would probably be much greater than the amount needed for air-conditioning.

Grande Ecaille Sulphur

Freeport Company Develops a New Deposit

THE Grande Ecaille salt dome, as pointed out by Wilson T. Lundy, of Freeport, Tex., is in the tidal marsh of the Mississippi River delta in Plaquemines Parish, La. Acquisition of the sulphur rights was effected by the Freeport Sulphur Company in April, 1932, and within a year eighteen wells were drilled and sampled.

Floating drilling equipment was employed. Two welded steel barges were specially designed to support the house and the entire drilling units. Each unit consisted of a 96-ft. derrick, a 100-hp. engine for the draw-works, a 50-hp. engine for the slush pump, an electric lighting system, mosquito blowers, a water pump, and tools and equipment for a rotary drilling rig. The derrick and draw-works engine were mounted on an 8-ft. steel substructure, which allowed space beneath for pumps and other equipment.

In the prospect drilling, the entire thickness of the cap rock overlying the salt plug was either cored or sampled by other means, so that a maximum amount of the formation might be removed for observation and analysis. Two sampling methods were found practical, the reverse return or air-lift system and the continuous operation of core bits used in conjunction with a sand pump.

The cap-rock area within the 2,000-ft. contour as outlined by the torsion balance totals 1,100 acres. Of this area, only 209 acres has been drilled and proved to contain sulphur in commercial quantities. The remaining undrilled area is considered a promising potential.

During the prospecting period the engineering department prepared and carefully studied several tentative plans for equipping this property. The plan adopted consisted of heavy reinforced concrete mats supported by piling for building foundations, and hydraulically made fills for the vat foundations and mining area. The vats are also supported by piling.

Investigation developed that water comparatively low in salt content could be obtained from the Mississippi, so a 50,000,000-gal. earthen reservoir was built for settling the turbid water before pumping it to the plant.

Power plant and other permanent buildings are built of steel with corrugated asbestos roofing and siding, using aluminum bolts and clips of high tensile strength for fastenings. Owing to the exposed location, the steel frames are designed for 125-mile winds. All window sash is galvanized steel, and gutters and downspouts are of aluminum, to minimize corrosion effects.

All Gulf Coast sulphur mines are highly variable in productive capacity. With similar plant capacities, production of one mine rarely equals that of another. It varies from day to day, and no area or even individual wells yield identical results. This variation is due primarily to the ever-changing thermal efficiency of the rock structure into which the water or heat is injected. Many factors upon which little or no control can be exercised enter into the thermal efficiency of individual deposits, areas, or wells. Major factors are probably the physical nature of the rock structure, rapidity of subsidence, reserves, concentrations, and recovery of sulphur. An estimate of the rate of production from Grande Ecaille is, therefore, difficult to determine.

Houghton Contributes

A New Instrument for Geophysical Work

DURING 1933, a new geophysical instrument known as the magnetic gradiometer, was developed by Irwin Roman and T. C. Sermon, both of the Michigan College of Mining and Technology, at Houghton. It was designed for determining the space rate at which the earth's magnetic field is changing. It consists of two similar coils rotating around parallel shafts in such a manner that the planes of the coils always remain parallel. For the reason that the electromotive force induced in a coil is proportional to the field in which the coil rotates, the ratio of the fields at the two coils may be measured by the ratio of the two electromotive forces. This ratio is measured by a specially devised Kirchhoff net.

So far as is known, no work has been done with such an instrument, all previous surveys having been carried out with a single instrument moved from one point to another. The present instrument was constructed to test the possibilities of the method and not to investigate the refinements. By actual tests it has checked the theory beyond expectations. Examples of the field tests indicate what can be done.

The frame of the machine is oak, about 5½ ft. long and 18 in. wide. Across its center is the main driving shaft, terminating on one side in a crank handle for turning both coils at the same rate. The coils are kept in parallel planes by proper adjustment of various gears and are about 4 ft. apart. They also are of oak, each 9-in. inner diameter and 12-in. outer diameter, with a groove about ½ in. deep and 1 in. wide. Each is wound with 375 turns of No. 22 copper wire, cotton-covered and paraffined. To make them waterproof, the entire coils were varnished.

Each coil is connected to a commutator rigidly mounted on its shaft. The commutator is of the double type and arranged so that when the brushes are placed on the center sections, it acts as a reversing type; when the brushes are placed on opposite outer sections, it acts as a pair of slip rings. Thus, by properly arranging the brushes, either direct or alternating current may be taken from the coils. The brushes are of the usual carbon type, each being carried in a bakelite brush cap threaded through a brass brush block which may be set at any azimuth around the coil shaft.

The circuit box carries the four resistance boxes and the reversing switch. One resistance consists of a four-dial decade box with a least count of 1/10 ohm. The other three resistances consist of three-dial decade boxes with a least count of 1 ohm. A slip cover protects the top of the circuit box when not in use. The reversing switch is mounted on the side of the box.

The galvanometer is a Leeds & Northrup 2400 *A* type, with a telescope and scale. Under favorable conditions, it has been possible to detect a current of the order 10^{-9}.

Magnetic Surveying

IN MAGNETOMETRIC SURVEYS the most important step is that of collecting the magnetic data, according to C. O. Swanson, of the Michigan College of Mining and Technology, whose experience in such work on the Michigan iron ranges stretches over the last ten years. This requires a suitable adjustment of the dip needle, and sufficient readings accurately to portray the field variations. With the readings clearly plotted, their interpretation is a matter of noting their relationship to the geological data. Mr. Swanson uses empirical relationships established separately for each area.

What It Cost to Open The Reno Mine ... The Modest Start of a Successful Gold Producer

T. J. Mateer

Consulting Mining and Metallurgical Engineer
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Fire destroyed this the original Reno mill in February, 1932

AN ACCOUNT of the development and equipment of a small mine, especially if costs are included, may yield data of more practical value in opening up the average property than information regarding work conducted on a larger scale. In the case of the Reno gold mine, the property, which is in British Columbia, is isolated, the conditions as to topography and climate are severe, the expenditure of money has been relatively small, and, finally, the outcome, despite these difficulties, has been successful. In the early stages of exploration, construction and operation the work was under the direct supervision of O. C. Thompson and Vernon Nielly, respectively managing director and superintendent of the Reno Gold Mines, Ltd., which reopened the property as a prospect in 1928, and has owned it ever since. When I first went to the Reno in October, 1931, the expansion period was already under way. In February, 1932, the 25-ton cyanide plant on the property burned, whereupon the company bought and rebuilt the Motherlode mill, which is in service today. Through the courtesy of Mr. Thompson, this article is presented. It describes the successful development of the enterprise, including the operation of the old mill. The cost data presented may be of interest.

The Reno mine was discovered in 1912 by prospectors after the surface had been exposed by bush fires. It is about 16 miles from Salmo, British Columbia, and is at the upper end of Fawn Creek, in the Sheep Creek camp of the Nelson Mining Division. Plant and mine openings are on the west slope of Reno Mountain, which is very steep at this point, and the site is in a belt of heavy snowfall. Mine workings lie between 6,300 and 7,100 ft. elevations. Within easy hauling distance is an ample supply of standing timber. In the immediate neighborhood of the mine, a forest fire has left many fallen trees. Save for rough mine timber, all supplies are hauled from Salmo on the Great Northern Railway. For the first 11 miles the road to the property follows the valley of Sheep Creek eastward at a good grade, and then ascends at an average grade of 10 per cent to the mine in the remaining 5½ miles, winding around the mountain. In it there are eleven switchbacks.

Inasmuch as the problem of transporting equipment and supplies is one that confronts a mining company from the outset, it may well be considered first. Supplies are handled in summer by a 1½-ton truck, which can make two round trips from mine to Salmo in about 12 hr.; but from Nov. 1 to April 1 all necessary supplies are brought by truck to the foot of the mountain, to which point the road is kept open. They are then transferred to a caterpillar-tractor-hauled sleigh for the trip to the mine. The snow in the valley goes off six weeks to two months before it disappears at the mine, and during this period the transfer point works up the valley with the snow line. During the snow season the road is kept open from mine to valley by the Reno company by means of a rotary snowplow propelled by a 5-ton caterpillar tractor. Supplies are hauled by a 2-ton caterpillar.

In summer the small tractor caterpillar is used for gathering mining timber and firewood for lime burning and domestic purposes. Save for a few heavy pieces brought in on a wagon hauled by a caterpillar, all machinery and supplies are handled by trucks.

Transportation costs are given in Table II. They include insurance and taxes but not depreciation or interest.

Data are not available to permit converting these figures into accurate per ton or per ton-mile costs. Rough estimates indicate a ton-mile cost of 55c. For about six months the truck handled all supplies from Salmo to the mine and returned empty diesel oil drums and the like, as well as a small tonnage of gold concentrates; and for about six months it handled supplies to the foot of the mountain and part way up at times, in each case transferring to the smaller tractor. During the open months this caterpillar was used part time gathering wood, handling lime, and transporting mine supplies from the camp to the upper tunnel portal. All this cost is included in the figures given. The truck has been in service about four years and is in fairly good condition.

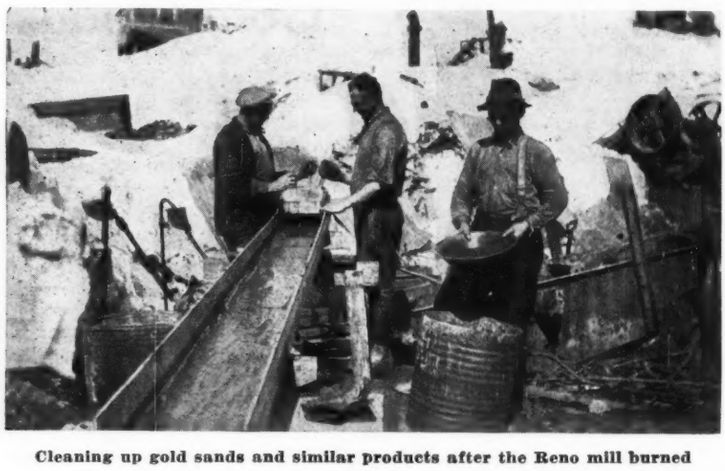
Total cost of handling supplies, of which the major item was diesel fuel oil, distributing these supplies at the mine, gathering rough timber for mining and domestic use, returning empties and concentrates to Salmo, and keeping the road from the mine to the valley open, was $9,404 for 1931, or 78.7c. per ton milled, when treating 33 tons per day.

Comparison of the figures shows the variation in over-all costs between winter conditions at $1,789 per month, aver-

age yearly costs at $784 per month, and summer costs at $516 per month.

In years of abnormally heavy snowfall the cost of keeping the mine road open would be increased. February, 1932, was exceptionally severe, with almost continuous snowfall and five severe storms, which closed the roads once, and five days' work with a large part of the mine crew and the snowplow were required to get them open. Costs for the month are given in Table I.

Since its purchase the Motherlode mill has been connected with the mine by a tramway 2½ miles long. As a result of this and the erection of a remote-controlled hydro-electric power plant on Sheep Creek, with the subsequent electrification of all mine machinery, the mine road is now abandoned in the snow season.



Cleaning up gold sands and similar products after the Reno mill burned

Table I—Cost of Keeping Mine Road Open, February, 1932

Truck	$250.01
2-ton tractor	571.77
Snowplow, 5-ton tractor, and labor	1,650.16
Workmen's compensation	23.98
Total	$2,495.92

The ore at the Reno occurs in quartz-filled fissures in Cambrian formations, mainly quartzites. Gouge is lacking. In width the veins vary considerably. The principal one, known as the Reno, is mineralized throughout, almost its entire length, though in places it is not commercial. Working shoots or stopes vary in thickness from 12 in. to over 4 ft., the vein filling being hard quartz frozen to the walls, with disseminated sulphides of lead, zinc, and iron. Except in a few isolated places there are no well-defined walls, and to ensure getting the pay values it is necessary to shoot about 6 in. of both hanging wall and footwall.

Both the Reno and the Donnybrook veins, the latter as yet unexplored underground, strike about N. 75 deg. E. and are almost vertical. The former does not outcrop, but was picked up on the third level by crosscutting after following several smaller veins shown on the surface. On the first level it pinches out about 30 or 40 ft. from the surface. Strike of the formation through which the two veins cut is about N. 15 deg. E. and the dip about 80 deg. E. throughout the mine. Oxidation, complete on the first level, lessens with depth, all ore on the No. 5 level being sulphide.

Early exploration consisted of surface cuts and trenches and about 880 ft. of tunneling on the first four levels. All of this labor was manual. Total expense, spread over some years, was $22,661.

When the property was taken over in 1928 by Mr. Thompson and associates, work was actively begun. The road to the camp, already partly constructed by the Province, was extended and repaired and the present camp was built. The latter consists of a three-story bunkhouse for 50 men, a cookhouse and dining room, and a two-story office building.

A portable gasoline compressor was placed at No. 4 level portal, and work started there in November, 1928. This level, already driven about 430 ft., had not cut the vein, which was now picked up by crosscutting several rounds to the north, and then followed, at the same time as the vein was followed on No. 3 level.

Extraction tests were made by the Mines Branch of the Department of Mines at Ottawa, and private interests. In March, 1929, the 25-ton cyanide plant was ordered from the Southwestern Engineering Corporation, Los Angeles.

Up to the time of starting this plant in August, 1929, approximately 1,375 ft. of 5x7-ft. drifting and 165 ft. of 13x5 ft. raising had been done by Mr. Thompson at a cost of $29,912, or 43.4c. per cubic foot.

This original plan included the following:

1 15x9 Blake type crusher
1 Southwestern feeder
1 4½x4½ ball mill
1 18 in. by 11 ft. Dorr classifier
4 18x8-ft. Dorr thickeners
3 10x12-ft. Dorr agitators
1 Zinc shaving box
1 100-hp. Crossley diesel engine
1 20-kw. electric generator

with necessary tanks, pumps, ore bins, elevator, zinc lathe.

The plant building was galvanized iron clad and also housed the power and air equipment.

Snow shoveling to clear the site was started in April, 1929, and the mill began grinding late in August.

During this time a sorting grizzly, waste chutes, and storage bins were erected near the portal of No. 4 tunnel, with a jig-back tram for transporting sorted ore to the mill bins below. The assay office and gold-melting department and an oil house were also built. This finished the development period and brought the property to the preliminary operating stage in 10½ months.

To Aug. 31, 1929, the cost of development, plus machinery and construction, was as given in Table III.

In September, 1929, the mill, designed for 25 tons daily, treated 702 tons, the average rate for the second half being

Table II—Transportation Costs at Reno Mine

	1931		1932	
	Monthly Average	12 Mos.	Average June and July	Jan.
Truck Operation				
Driver	$194.97	$2,339.70	$246.70	$186.64
Gasoline and oils	98.51	1,182.10	123.10	116.11
Repairs	116.68	1,400.14	76.27	225.94
Totals	$410.16	$4,921.94	$446.07	$528.89
Tractor Operation (2 ton)				
Driver	.....	$1,209.33	$45.14	$170.00
Gasoline and oils	.....	559.76	13.19	154.80
Repairs	.....	795.47	11.26	127.60
Totals	.....	$2,564.56	$69.59	$452.40
Per month	.....	213.71	69.59	452.40
Snowplow and 5-Ton Tractor Operation				
Driver and helpers	.....	$1,083.53	Nil	$588.98
Gasoline and oils	.....	411.26	.....	105.50
Repairs	.....	357.37	.....	98.95
Totals	.....	$1,854.16	.....	$793.43
Per month	.....	154.51	.....	793.43
Workmen's Compensation	.....	$64.63	.....	$14.24
Total Transportation	.....	$9,404.09	$515.66	$1,788.95
Per month	.....	783.87	515.66	1,788.95
Per ton ore milled	.....	0.787	.....	.....

Table III—Cost of Development, Machinery and Construction

Exploration before acquisition of control of property by O. C. Thompson *et al* ...	$22,661
Development Nov., 1928, to Aug., 1929..	29,912
Machinery and construction.....	77,988
Administration.....	11,804
Total.....	$142,365

28 tons per day. Gold extraction for the month was 94.8 per cent.

Returns from first bullion shipped were not received until early in November, so to the total given in Table III should be added about two months' working capital, with cost of stores and inventories, or about $35,000, making a total of about $177,365 to bring the property to self-supporting operation. The amount available was $183,985. As operations developed, more air was required, and a 130-hp. Crossley diesel, direct-connected Sentinel, 650-cu.ft. compressor was installed. Further development disclosed that with both penetration along the vein and depth the zone of oxidation was passed and the orebodies were hard sulphides, making the drilling more difficult. Another air unit consisting of a 90-hp. semi-diesel engine belted to a 500-cu.ft. Ingersoll-Rand compressor running at about two-thirds normal speed was therefore installed.

When oxidized, the ores show free gold, but none is visible to the eye in the sulphides, although it shows up on the tables when milling sulphides.

When the sulphide ores reached the mill the tailing loss increased, and three blanket strakes were put in, to be followed later by two Wilfley tables. As soon as the ore reserves were large enough, the 18-in. classifier was replaced by a 36-in. by 16-ft. Dorr classifier, so that more ore could be ground, and the mill capacity increased to about 50 tons per day.

A set of barrels, with hoods, and filter boxes was set up for acid-treating the gold precipitate.

Much of the gold recovered was obtained by closing down the ball mill once a month, cleaning out the grinding circuit, and concentrating the resultant sands on a California rocker. An amalgamation barrel, 28x30 in. inside dimensions, was installed for amalgamating these concentrates, as well as those from the blankets and the tables.

Tests show about 50 per cent of the gold is recoverable by straight amalgamation. Distribution of recoveries in the old mill was as follows:

	Per Cent
By cyaniding	52
By amalgamation of clean-up sands, and concentrates	40
Table concentrate (middling)...	8

Over-all recovery was about 93 per cent. In early operations on oxidized ores it was 95 to 96 per cent, and tests indicated that finer grinding and a longer agitation period would raise extractions on sulphide ores to +96 per cent.

To December, 1931, heads averaged $17.31 per ton, and for the last five months of operation before the mill fire, $22.80 per ton.

In milling, the ore was crushed to about 1¼ in., elevated to a steel fine-ore bin, and fed to the ball mill operating in closed circuit with its 36 in. by 16 ft. Dorr classifier and ground in cyanide solution. Classifier overflow was 50 tons per day at 56 per cent minus 200 mesh, assaying 0.37 oz., and classifier return about 200 per cent. The overflow was treated on two standard Wilfley tables, making a lead concentrate carrying 100 to 150 oz. gold per ton and a middling carrying about 7 oz. gold per ton, the tails assaying 0.22 oz. The middling was sold to the smelter, but as tests showed a 96 per cent extraction by cyanidation, plans were being made to cyanide it. The lead concentrate was amalgamated in the clean-up barrel and the residue sold to a smelter.

Table tails were elevated by pump and run over three blanket strakes, feeding No. 1 thickener, and the blanket concentrates amalgamated if high grade, or sold to the smelter if low grade.

No. 1 thickener overflow was clarified by suction leaf filters and run through two zinc boxes. These were cleaned twice a month, the gold precipitate was treated with sulphuric acid, dried, and refined in an oil-fired graphite crucible furnace, to which the sponge gold, secured by retorting amalgam, was added, and the bullion bars were shipped to the mint.

Thickened pulp from No. 1 thickener was pumped by a Dorrco suction pump to the first of three Dorrco agitators in series and then passed through three Dorr thickeners arranged for counter-current washing, with the final tails being discharged to the tailings dump through a flume about 1,600 ft. long.

No. 5 tunnel was started in the summer of 1931, and when it cut the vein a trestle was built connecting its portal to the mill ore bins while a sorting grizzly with chutes was built at the latter point. This, the third, stage was completed by December, 1931, and in addition to doing mine development work costing $57,900, a surplus of $78,400 was built up.

Table IV—Milling Costs for 1931

Ore sorting.....	$0.130	Reagents.....	$0.354
Crushing.....	0.198	Power and air...	0.856
Grinding.....	0.631	General expense.	0.097
Tabling.....	0.059	Refining and	
Blanketing.....	0.056	amalgamating.	0.118
Settling.....	0.230	Superintendence.	0.268
Agitating.....	0.114	Assaying.....	0.174
Clarification.....	0.053	Workmen's com-	
Precipitation.....	0.182	pensation.....	0.028
		Total.....	$3.548

Average tonnage, 995 per month.
Ball consumption (4-in. chrome forged balls) 2.55 lb. per ton ore.
Sodium cyanide, 17c. per pound f.o.b. Salmo.
Lime, $20 per ton.
Labor, mill men $4.50 per 8-hr. shift.

Capital expenditures to Dec. 31, 1931, are given in Table V. Total expenditures, summarized by stages, are given in Table VI.

From the figures presented, one sees that the total cost, without working capital and stores inventory, of developing the Reno mine from a prospect, installing mine machinery, buildings and equipment, providing power, building a 25-ton cyanide plant and improving it to 50-ton capacity was $191,268, of which $183,985 came from original capital and the remainder from earnings. They also show that during the third or expansion stage $56,872 was spent on development and charged to expense and a current surplus of $78,000 built up. (Stores inventory was about $12,000. All mine tools were charged to expense when put into service and rails, pipe, and like equipment to development.)

Transporting the aerial tramway cable from the railway to the mine, Reno Gold Mines, Ltd., British Columbia

Underground development is done by drifting on the vein and by raises with occasional crosscuts. In drifting, Ingersoll-Rand R 72 drifters are used. Faces are usually dry. Small faults and slips are frequent, some of which have caused small displacements of the vein, usually to the north, but these are not troublesome. However, at a number of places splits occur in the vein, and

Table V—Capital Expenditures to Dec. 31, 1931

	Buildings and Structures	Machinery Equipment	Total
Assay office and gold refinery	$537.98	$1,555.71	$2,093.60
Blacksmith shop	642.61	2,084.95	2,727.56
Portable compressor	.....	4,969.75	4,969.75
Underground diamond drill	.....	1.584.15	1,584.15
Mine cars	.....	519.50	519.50
Mine hoists	.....	1,173.53	1,173.53
Mine and general supply pumps	.....	797.79	797.79
Rotary snowplow	.....	2,871.00	2,871.00
Tractors	.....	7,396.31	7,396.31
Truck	.....	3,178.20	3,178.20
Cyanide plant	16,223.45	34,051.05	50,274.50
Power and air	.....	27,557.03	27,057.03
Electrical	.....	2,041.53	2,041.53
Miscellaneous—Fire protection, gasoline pump, phone	50.00	485.20	535.20
Aerial tramway—jig-back	2,194.51	.....	2,194.51
Boarding house	2,097.54	825.66	2,923.20
Bunk house	3,491.35	1,125.63	4,616.98
Office and staff house	1,324.05	1,989.28	3,313.33
Camp clearing	109.25	.....	109.25
Camp water lines	971.10	.....	971.10
Garages	504.53	.....	504.53
Lime kiln	319.17	.....	319.17
Roads and trails	661.31	.....	661.31
Oil house	153.91	.....	153.91
Pump house	221.51	.....	221.51
Powder house	32.84	.....	32.84
Warehouses	261.69	.....	261.69
Superintendent's residence	813.90	459.38	1,273.28
Trestle No. 5 level	467.08	.....	467.08
Winter road (1¼ miles long)	1,147.77	.....	1,147.77
Totals	$32,225.55	$94,665.65	$126,891.20

Table VI—Total Expenditures, Summarized by Stages, to Dec. 31, 1931

Preliminary exploration, first stage	$22,661
Mine development to start of milling, second stage	22,912
Machinery and construction to start of milling, second stage	77,988
Administration, second stage	11,804
Machinery and construction from start of milling at 25 tons per day to mill capacity of 50 tons per day, third stage	48,903
Total	$191,26

the men must guess which one to follow. Usually a few rounds gives the necessary information.

Main raises are 16x5 ft., driven by Ingersoll-Rand R 51 self-rotating stopers. Some follow the vein, but the raise between No. 4 and No. 5 level was driven straight and cut through the vein. In raising, particularly in stopes, some small, steeply dipping faults are met. These are nearly parallel to the vein but 10 to 15 deg. off its dip. As they are small and displace the vein vertically for 10 to 30 ft. without making any easily noticeable gouge, they are hard to distinguish from a pinch in the vein and are likely to be mistaken for a pinch in the orebody. They usually show a little slickenside on the hanging wall of the ore.

In 1931, 1,469 ft. of drifts, crosscuts, and raises were driven. These were of various sizes, and the average cost was $15.13 per foot. Cost of driving the first 1,086 ft. of No. 5 tunnel, 7x5 ft. in cross-section, is given in Table VII.

Diamond drilling in 1931 totaled 2,456 ft. A Mitchell drill making a ⅞-in. core was used. The holes, all underground, were 30 to 500 ft. long. Costs per foot are given in Table VIII.

Shrinkage stoping is employed, with about 25 per cent of the break drawn as the stope is extended upwards to the level or sublevel. The walls stand without support. Ingersoll-Rand self-rotating R 51 stopers are used.

Draw chutes are spaced on 15-ft. centers. At the tunnel levels, if the ore in the back is high grade, it is backstoped and timber flooring is placed on stulls. Where the ore is lower grade, pillars are left between chutes or box holes. Mining costs for 1931 are given in Table IX.

Table VII—No. 5 Tunnel Cost Per Foot

First 1,086 Feet

Breaking ground	$6,071.67
Timbering	720.86
Air drills and steel	999.63
Power and air	1,773.17
General underground including foremen, waste disposal track, and pipe lines	3,644.71
Superintendent	163.33
Assaying	41.94
Surface expense	274.59
Workmen's compensation	235.24
	$13,925.14
Cost per foot	$12.82

Table VIII—Diamond Drilling Costs

	Per Foot
Operator	$0.399
Carbons	0.211
Oil and grease	0.008
Repairs	0.053
Workmen's compensation	0.006
Power and air	0.181
Total	$0.858

Table IX—Mining Costs for 1931

	Per Ton
Ore breaking	$1.814
Timbering	0.230
Hoisting	0.029
Air drills and steel	0.449
Power and air	0.603
General underground, including foremen	0.551
Superintendent	0.070
Sampling and assaying	0.066
Surface expense	0.115
Workmen's compensation	0.050
Total	$3.977

Steel, 11c. per lb. f.o.b. Salmo.
Powder, 15c. per lb. f.o.b. Salmo.
Miners, $4.50 per 8-hr. shift.
Laborers, $4 per 8-hr. shift.
Cost of explosives 97c. per ton.

Costs are based on tonnage of ore after sorting and do not include ore transportation. Average monthly tonnage was 995.

Ore drawn is hand trammed in 20-cu.ft. cars to the sorting grizzly and about 25 per cent waste picked out.

Cost of operating the two oil engines that drive the mine compressors was 1.35c. per brake horsepower, without allowance for depreciation. This is calculated for 107,520 brake horsepower-hour (in which no deduction has been made for the light loads carried when the compressors were unloading). The engines were a 130-hp. Crossley diesel and a 90-hp. Petter semi-diesel. The items entering this cost are given in Table XIII. Cost of fuel oil was 14.88c. per gallon at the mine. Lubricating oil cost 54.5c. per gallon.

Development cost per ton ore based on ore removed and broken ore reserves is about $1.50 per ton.

Mill power is supplied by a 100-hp. Crossley diesel. The cost for December, 1931, an average month with full load conditions, is given in Table XII.

Development drifts and raises when on ore are sampled every round by face cuts. The assays are weighted, using

Table X—Ore Transportation Costs

	Per Ton
Hand tramming—underground	$0.283
Car repairs	0.010
Jig-back tram operating	0.128
Jig-back tram repairs	0.006
Workmen's compensation	0.008
Total	$0.435

Table XI—Operating Expenses, 1931

Per Ton Ore Milled

Mining	$3.977
Ore transportation	0.435
Milling	3.548
Marketing	0.362
Bullion tax	0.227
Administration	0.961
Miscellaneous expense	0.190
Total	$9.700

Table XII—Power Costs, Mill Engine December, 1931

	Labor	Supplies	Total
Operators	$167.40	.....	$167.40
Fuel oil	.....	$501.59	501.59
Lubrication	.....	83.20	83.20
Repairs and overhauling	46.74	89.07	135.81
Workmen's compensation	3.65	.....	3.65
Totals	$217.79	$673.86	$891.65
Brake horsepower-hours	.....	57,600	.....
Cost per b.-hp. without depreciation, cents	.....	1.55	.....

Table XIII—Compressor-Diesel Power Cost, 107,520 B.-Hp.

	Labor	Supplies	Total
Operators	$251.10	.....	$251.10
Fuel oil	.....	$773.01	773.01
Lubrication	.....	124.80	124.80
Repairs and overhauling	99.02	198.13	297.15
Workmen's compensation	5.47	.....	5.47
Totals	$355.59	$1,095.94	$1,451.53

the foot-percent method, and probable gold contents of each block recorded.

Grab samples are taken from every car of muck and the assays from each stope recorded.

Since these stope-muck samples have been recorded two stopes have been mined and completely drawn, showing the results given in Table XIV.

Average weighted muck samples, 1.109 oz. per ton.

Mill recoveries plus tails divided by tons milled, 1.113 oz. per ton.

In February, 1932, the mill was destroyed by fire. The loss was covered by insurance, and a use and occupancy policy was also carried. Under this latter policy the company collected estimated profits for a rebuilding period of six months.

The Motherlode properties, including Motherlode mine, Nugget mine, and the Motherlode mill, were purchased in 1932. During the summer of that year this mill, built in 1912, was rebuilt and modernized and connected to the Reno mine by a 2½-mile aërial tram while a remote-control hydro-electric power plant with 16,000 ft. of water flume and necessary power lines was built on Sheep Creek about 6 miles below the Motherlode mill.

Table XIV—Sampling and Milling Results Compared

	Stope A	Stope B
Area, sq. ft.	17,442	20,294
Average width sampled, ft.	2.020	1.945
Contents, cu.ft.	34,884	39,472
Calculated tons	2,683	3,035
Sent to mill, tons	3,447	3,825
Drift sample assay, oz.	0.548	1.430
Estimated gold, oz.	1,470	4,341
Muck assay, oz.	0.510	1.27
Gold mined, oz.	1,758	4,858
Appreciation, oz.	288	517
Appreciation, per cent	19.6	11.9
Width mined, ft.	3.43	3.26
Overbreak, ft.	1.41	1.32
Tons to ore bin before sorting	4,596	5,100

For the last three months of mill operation before the fire, muck samples were weighted monthly and checked against mill returns.

The new mill went into operation late in December, 1932. It is designed for 75 tons per day along the lines of the Reno mill, the main differences being two-stage grinding instead of one-stage, elimination of blankets, retention of table middlings in the cyanide circuit, use of Merrill-Crowe precipitation process instead of zinc boxes, and use of Merrill slime presses, which were part of the old Motherlode equipment, for early operations.

The Reno vein is increasing in strength and grade on its dip. This, with the prospects of the unexplored Donnybrook vein and the known ore possibilities of the Motherlode and Nugget properties, is expected to provide tonnage for a larger operating program with very material reductions from the costs shown herein for the early 33-ton per day operations, which costs are being bettered considerably with the present 75-ton daily capacity.

A Washing Plant on Wheels

Designed to Service a Narrow Pit

An end view of the crane. Behind it the washing plant

NEAR GILBERT, MINN., on the Mesabi, is the Malta and Malta Annex iron mine. This property was listed as exhausted in 1927, having formerly been operated by Pickands-Mather Company, with an extraction of more than 1¼ million tons of ore by open-pit and underground mining. As soon as the company named abandoned the property, the fee owners threw it open for some small contractor to work for the 100,000 tons of ore remaining, that was to be won only with difficulty.

The open pit is a long, narrow, crooked cut having only a small amount of ore. The large body of wash ore was some distance away and could be recovered only by stripping part of it and removing the rest by drifting. Thus, the problem was how to wash this ore economically with the deposits so far apart and the pit too narrow for railroad grades.

A contractor from Duluth, Walter Bowe, conceived the idea of using a washing plant on wheels that could be fed by a large gantry crane which he could secure cheap from the defunct McDougal Shipbuilding Company. The washer was of the Dorr type formerly used at the exhausted Mariska mine, near Gilbert. It consists of a trommel partly submerged in a steel tank containing 8-ft. rakes that wash and discharge the concentrates to the shipping bin. By placing the washer in a timber structure on wheels supported on 100-lb. rails, which also form the track for the gantry crane, then adding the crane, which has a boom swing of 75 ft. and a lifting capacity of 10 tons, a washing equipment was secured that could handle 75 tons of concentrates per hour and could easily move to either end of the pit.

After stripping with the crane in 1929 Mr. Bowe started the plant in 1930 and shipped over 27,000 tons. Ore was not in demand for the next two years, but this season he is busy again and has shipped over 20,000 tons. He is planning to use an electric motor to replace the steam hoisting engine on the gantry crane and to add a hydrotator to the washer to recover more of the 100-mesh and finer ore.

The pictures here presented, reproduced from photographs, give an idea of the close quarters in which the plant operates. Besides picking up the ore buckets and dumping them in the top of the washing plant, the crane is used in stripping, in coaling shovels, and in handling heavy machinery in need of repairs. Water for washing is secured from an abandoned shaft 1,500 ft. away with an electric pump and a 4-in. discharge line. All the washing plant machinery is electrified. For its size this is one of the most active pits on the range this season.

The washing plant adjacent to the gantry crane, which supplies it with ore

Rock Asphalt

John B. Huttl
Assistant Editor

MINING ROCK ASPHALT in Santa Cruz County, Calif., dates back to the 'nineties. The deposits resemble those at Kyrock, Hardin County, Ky. Prior to 1904, the known beds were exploited steadily and the rock was sold for paving purposes. At that time such material was applied hot to the roadbed. With the adoption of the cold paving process, demand for rock asphalt increased, and the present lessees of the properties, the Calrock Asphalt Company, of San Francisco, modernized their quarrying methods and built a new processing plant. This was in 1930. Quarries and plant are situated 5 miles northwest of Santa Cruz, on a branch line of the Southern Pacific Railroad.

Above, Processing plant of Calrock Asphalt Company. Below, Breaking the rock asphalt for loading.

The deposits occur as flat beds varying from a few inches to more than 80 ft. thick, underlying and imbedded in Monterrey shale. Disruption of subterranean oil pools by faulting of the earth's crust, evidently, forced the oil up and flooded the sand beds, which were transformed gradually into a residue of hard bituminous sandstone by a natural process of distillation and evaporation. The beds dip at a slight angle toward the ocean. Major step faults along lines parallel to the shore have given the surrounding country a terraced appearance, and at these points the exposed beds afford good sites for opening quarries. The rock, as mined, is dark gray to black and contains 10 to 14 per cent asphalt.

Overburden varies greatly in character and thickness. It is composed of surface soil and diatomaceous shale, with varying amounts of sand, clay, and sandstone. Stripping is done by a Marion 1 steam shovel, having a $\frac{3}{4}$-cu.yd. dipper, and 5-ton dump trucks. Occasionally, the operators must resort to drilling and blasting.

Prospecting of the property, covering more than 600 acres, is done with Sullivan core drills. A comprehensive program is carried on intermittently. The equipment consists of a single-tube Size B core barrel, Size E drill rods, a standard water swivel, and cutting bits, each set having six welded-on Haynes Stellite teeth. Water is supplied by a gasoline-driven pump. The drill rod is driven at 150 r.p.m. by a small tractor, cutting speed and pressure upon the bit being regulated by weights. Cost per foot of hole is about 60c. One man operates the drill rig.

One producing quarry is about 600 ft. from the processing plant. Another has been opened a mile north of the plant, operations being limited to stripping work and building a drainage system. Here the asphalt bed is 45 ft. thick, the overburden averaging 10 ft.

Mining is done by standard quarrying methods, I-R S49 jackhammers and Ingersoll-Rand and Timken detachable bits being used. The bits are forged solid and have the water opening at the side instead of the bottom. This change in the position of the water passage has overcome the difficulty arising from plugged holes and gummed bits, so often experienced in drilling bituminous rock.

Use of detachable bits has reduced drilling costs materially, as it eliminated the drill sharpener and transportation of steel. The bits are in seven gage sizes, ranging in $\frac{1}{8}$-in. changes from $2\frac{1}{4}$ to $1\frac{1}{2}$ in. inclusive. Air is furnished by a C-P portable compressor connected to a pipe line encircling the quarry. Water is obtained from a tank above the quarry fed periodically by a Worthington triplex pump attached to the public waterworks main.

The holes, drilled to a maximum depth of 15 ft., are first sprung with 40 per cent dynamite and then loaded with black powder. Because of the rubbery character of the rock, a slow explosive was more effective. Powder consumption is about $\frac{3}{4}$ lb. per ton broken. The rock does not shatter well, and much blockholing is necessary. Small boulders are broken by hand.

Broken rock is loaded by hand into 5-ton trucks and hauled to the plant. Here each truck is dumped into a 15-ton wooden feed hopper. The rock then passes over a 36-in. pan feeder to a 18x32-in. Joshua Hendy roll-jaw crusher to be reduced to minus 3 in. This unit is well adapted to crushing bituminous material. As designed, the upper end of the jaw frame is mounted on an eccentric shaft, the lower end operating against an inclined toggle. As the curved jaw approaches the roll, it makes a downward movement, tending to rotate the roll and facilitate the discharge of the crushed rock. Standard jaw crushers proved unsatisfactory, as the asphalt tended to gum the crusher passages, with consequent loss of capacity.

The crushed rock is conveyed to a 200-ton storage bin, from which it is fed by a 24-in. pan feeder with swing-hammer control to a belt conveyor and discharged over a vibrating screen. The undersize, ranging from $\frac{3}{8}$ in. to dust, is then conveyed to the mixing plant, and the oversize goes to a swing-hammer mill, in closed circuit with the screen.

At the mixing plant the screened material is collected in a 3-ton storage hopper equipped with a hand-operated gate. From this it passes successively to a 2-ton hopper, containing a Fairbanks beam scale, and to a $1\frac{1}{2}$-ton pug mill. Fluxing oil, mineral filler, and other ingredients are added in calculated amounts to be mixed into cold paving material as specified. The finished product is discharged upon a 30-in. shuttle conveyor mounted on a traveling

carriage under the pug mill, which is rolled out over the spur track to facilitate loading gondola cars. These are spotted by means of an air winch, controlled from the mixer floor. When loading into trucks the conveyor is withdrawn. A driveway is provided under the pug mill for loading trucks.

Fluxing oil is stored in a 12,500-gal. steel tank. A 500-gal. surge tank on the top floor of the mixer building is fed automatically by an electric-driven pump controlled by a float switch. Thence the oil flows by gravity to the weighing bucket above the pug mill.

All plant machinery is driven by individual electric motors, one for each unit. The pan feeder below the 200-ton storage bin, all conveyors between there and the pug mill, and the screen are operated by a single magnetic switch, with dual pushbutton control on the mixing floor and in the crusher building. Thus the operator at the pug mill can start or stop the stream of material instantly.

Plant capacity is 250 tons of paving material per 8-hr. shift, two men being required per shift.

Acknowledgment for information and the accompanying photographic reproductions is made to J. E. Hayes, general manager, who provided them at the time of my recent visit to the plant.

Metallurgical Calculation Simplified

By Stencil Method

Alexander M. Gow

Assistant Metallurgist, U. S. Bureau of Mines, Mississippi Valley Experiment Station, Rolla, Mo.

A SIMPLIFIED METHOD which I have devised is now in daily use for calculating metallurgical recoveries of three products made from a mill feed when only the assays of each product are known.

In connection with centralized milling of lead-zinc ores in the Tri-State district, the U. S. Bureau of Mines, in cooperation with the Missouri School of Mines and Metallurgy, was called upon by the Office of Indian Affairs to recommend a recovery calculation by means of which an equitable royalty settlement could be made. Formerly, when each property had its own concentrator, an exact calculation was not necessary, because any error would be corrected at the time of a clean-up; but when a concentrator was to treat, simultaneously, ores from several properties, including Indian lands, to have a system of accounting which was rapid, practical, and theoretically correct became necessary.

Each trainload of mill feed is weighed and sampled before entering the concentrator, but thereafter the identity of the parcel is lost, as it is mixed with trainloads from other properties. However, zinc and lead assays of the zinc concentrate, of the lead concentrate, and of the tailings are made from each day's run in the mill; and each parcel of mill feed is sufficiently similar to the others of the same day to justify the assumption that the day's products truly represent those that would have been made if the particular parcel had been treated individually.

From the zinc and lead assays of the mill feed, or heads, and of the other three products, the relative tonnages must be calculated, inasmuch as an opportunity to weigh the concentrates produced each day seldom occurs. Mathematically, this is a simple problem in three unknowns; three simultaneous

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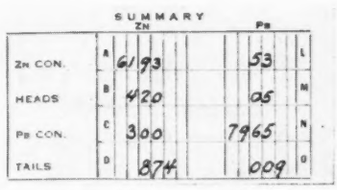


Fig 1—Summary table

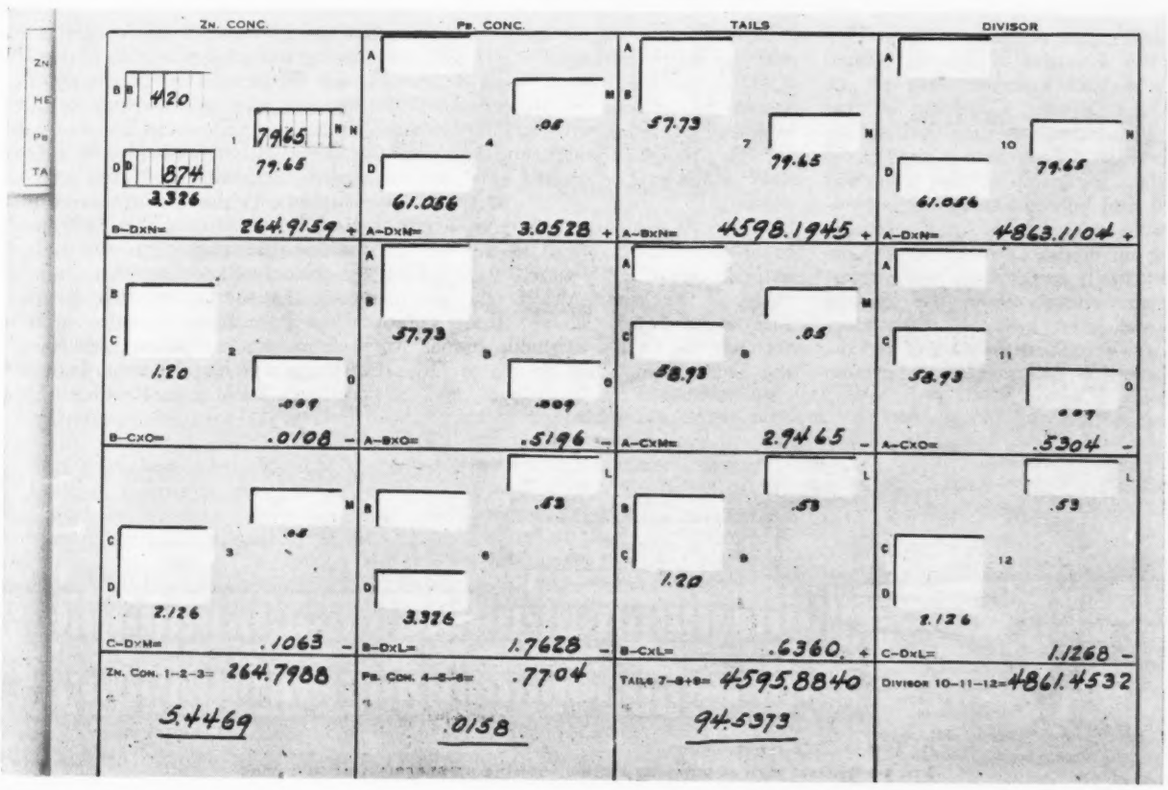


Fig. 2—Calculated stencil

equations may be solved algebraically; but such a procedure is too drawn out to be practical in routine accounting.

By algebraic simplication of the determinant solution, the following method was evolved:

The eight assays are set up in a summary table showing two columns of per cent of zinc and per cent of lead for each of the four products: zinc concentrates, heads, lead concentrates, and tailings (see Fig. 1). Each value in the summary table has a reference letter beside it.

In conjunction with this table is a stencil, made from stout cardboard or celluloid, in which are cut twelve arrangements of three holes each. Fig. 2 shows the stencil with the summary table placed underneath arrangement No. 1. Each of the twelve arrangements has two holes in the zinc column and one hole in the lead column; and, successively, each arrangement is placed over the summary table. Reference letters on the table are matched with reference letters on the stencil to insure the proper placement. Then the lower zinc value is subtracted from the upper zinc value and the difference is multiplied by the lead value, as indicated in the lower-left corner of the arrangement. The twelve arrangements are set up in four columns of three each. After the twelve multiplications have been made, each column is added according to the plus or minus signs marked on the lower-right corner of each arrangement. This gives four column totals. Dividing the first by the last and multiplying by 100 gives the percentage of head tonnage which became zinc concentrates; dividing the second by the last and multiplying by 100 gives the percentage which became lead concentrates; and, for a check, the third column may be divided by the last and multiplied by 100 to get the percentage which became tailings.

The relative percentages of each product having thus been obtained, the tonnage of the two concentrates—and the tailings, as a check—are figured from the head tonnage.

About fifteen minutes is required for the entire calculation at the calculating machine, and by erasing old figures one stencil may be used repeatedly.

The method has been adopted by the Eagle-Picher Mining & Smelting Company. The accompanying summary table and calculated stencil, showing how the technicians of the company use the method, is presented by their permission.

Pumping at Morococha

A. C. MacHardy

Superintendent, Morococha Unit, Cerro de Pasco Copper Corporation

THE main underground pumping plant of the Cerro de Pasco Copper Corporation's Morococha unit, at Morococha, Peru, has a total installed capacity of 30,000 g.p.m. and is situated on the 1,014 level of the Natividad mine, 14 ft. below the 1,000 or deepest working level of any of the mines in that district.

As originally designed, the layout was for 15,000 g.p.m. and was made in 1917 under the direction of Harold Kingsmill, who was superintendent of the Morococha Mining Company at that time. The design was such as to satisfy the worst conditions that seemed probable when the pump station level was reached and subsequent mining operations were started. However, with the opening up of the 1,000 level, the conditions actually encountered made necessary some alterations in the original plans, and later, in 1931, when more water was struck in the Ombla section, the plant was enlarged to its present capacity.

The pump station is serviced by the Natividad shaft, which is used exclusively for that purpose and isolated from other mine workings by means of concrete bulkheads on all levels up to the 400, or main drainage, level. On the 1,000 level, the station itself is protected by a solid reinforced-concrete bulkhead provided with suitable valves for the passage of water, and by a steel door which can be opened or closed as desired.

Water is discharged through a concrete-lined vertical raise to the 400 or main drainage level, which, with its 20 miles of workings, drains the entire Morococha area above that point through the Carlos Reynaldo tunnel, to the Tuctu Pampa and thence to Huascacocha Lake.

The station opens directly off the shaft and is 170 ft. long by 20 ft. wide, with two offsets of 12x45 ft. and 11x23 ft., to provide room for three extra pumps. The main part of the station has an arched section 13 ft. high at its central point and is timbered with 10x10-in. timbers spaced at 5-ft. centers. Ceiling and sides are lagged and fitted with watertight panels, which keep the station free from drip. A steel crawl extends the entire length of the station over the center line of the pumps. The general plan and arrangement of the timbering is shown in Fig. 1.

Ventilation is provided by a downcast raise connecting the rear end of the station with the 400 level, and by a suction fan situated at the shaft end of the station discharging into the shaft, which is upcast. Experience has shown, however, that the fan must be operated only when more than six pumps are in use.

Pumping equipment consists of nine 4-stage centrifugal pumps, each of which delivers 2,500 g.p.m. under a head of

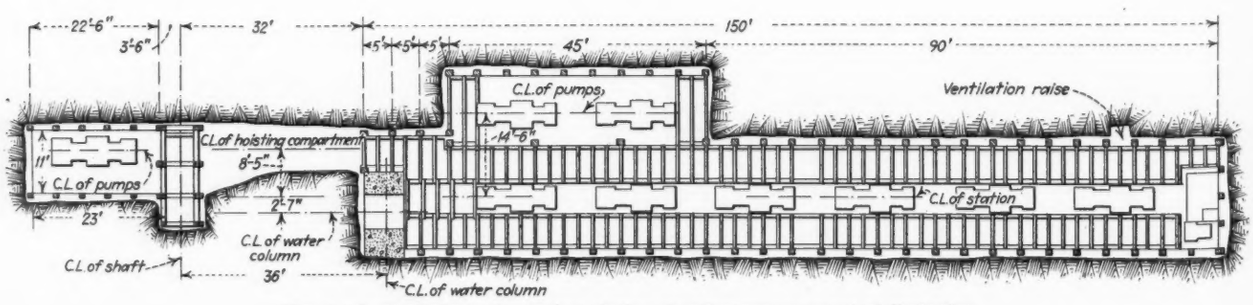


Fig. 1—General plan of pumping station showing arrangement of timbering

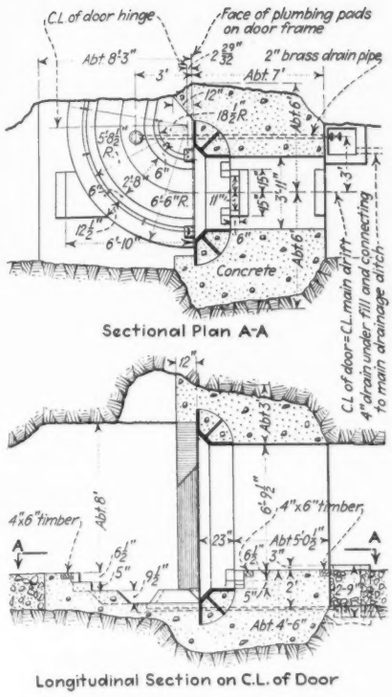


Fig. 2—Details of controlling bulkhead

520 ft., and one 24-in. 5-stage vertical, deep-well type, turbine pump, having a capacity of 7,500 g.p.m. at a head of 270 ft. This latter pump was used for unwatering the mines during the flooding, which occurred in 1924, but it has since been permanently installed in one compartment of the service shaft. It is used only as an auxiliary unit and discharges to the 750 level, where two booster units take care of the water from that point upward. Eight of the 2,500-gal. units discharge direct to the main drainage level through the concrete-lined raise, whereas the ninth, also an auxiliary unit, discharges through a 10-in. column in the shaft to the 750 level. Power is supplied to the 2,500-gal. units by 500-hp., 1,200-r.p.m. induction motors. The vertical turbine pump is equipped with a 900-hp., 1,200-r.p.m. slip-ring induction motor situated at the top of its discharge column on the 750 level. A 4-in. 500-gal. centrifugal station sump pump, operated by a 5-hp. induction motor, takes care of all drip and leakage water from the station itself and discharges back into the main sump.

All drainage on the 1,000 level is toward the Natividad shaft. Flow from the San Francisco side joins that from the Central, Gertrudis, and Ombla sections a short distance before reaching the controlling bulkhead, which is situated in a runaround crosscut from the main drift, leading from the Natividad to the Central shaft. A grizzly constructed of mine rails, placed across the main ditch, prevents small pieces of timber from entering the bulkhead valves.

The bulkhead is of solid reinforced-concrete construction, designed to withstand a head of 500 ft. Details are shown in Fig. 2. It is provided with four 14-in. valves for the passage of water and a manhole opening to facilitate cleaning and inspection. The valves are operated from the station side of the bulkhead, and a man is in attendance at all times, as the amount of water flowing to the pumps is controlled at this point. Telephone connection to the pump station is provided, and, as an additional precaution, an automatic float arrangement, which operates a red light and bell in the pump station, indicating allowable high-water level in the sump.

In the main drift, at a point between the junctions of the runaround crosscut, is a concrete bulkhead with a door, to provide for the passage of mine traffic.

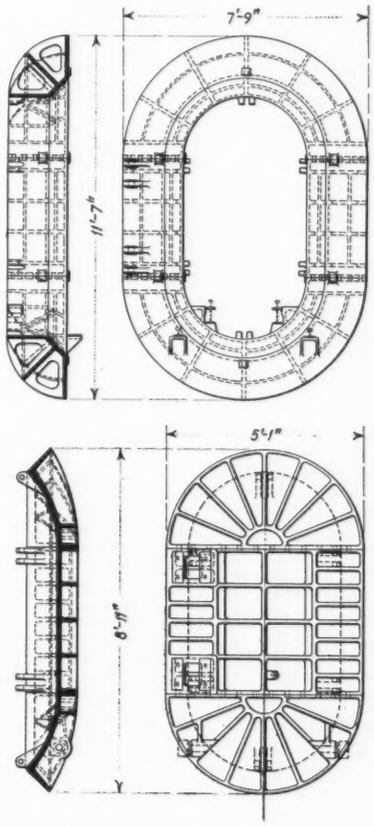


Fig. 3—Details of bulkhead door

The door is of steel construction designed to withstand a pressure head of 500 ft. Details of the door are shown in Fig. 3 and the general arrangement of the bulkhead is illustrated in Fig. 4. A vicinity map included in Fig. 2 shows the position of both bulkheads.

After passing through the bulkhead valves the water flows along a 4x7-ft. ditch 360 ft. to a screen chamber, where all floating foreign matter larger than ¼ in. is screened out. The chamber has two compartments, each provided with a gate so that the water may be excluded from either side to allow for the proper cleaning of the screens. The water then drops to a sump 12x12x63 ft. long, which is separated from the pump station by a wall of solid rock 12 ft. thick. The floor of the sump is at the same elevation as the main suction line to the pumps, or 20 ft. below the 1,000-level ditch line. With a full sump this arrangement gives a pressure feed to the pumps at all times.

Passing through the dividing wall, a 36-in. suction line runs below the floor of the station along its entire length, with 10-in. connections to each of the eight main pumping units. It is of bronze and wood-stave construction, all fittings being of bronze, with the intermediate lengths of wood stave. The entire line is encased in concrete. At the sump end of the station the line is provided with a 36-in. valve with 4-in. bypass. At the shaft end is a 30-in. extension and 14-in. valve, to provide a discharge connection from a possible future pumping plant at a lower level. A removable V-shaped section installed ahead of the 36-in. valve provides an entrance to the suction line under the station floor. At this point a 6-in. connection from the station sump pump and from the end of the main discharge line provides a means of draining the discharge column back into the sump when necessary. The two auxiliary pumping units have no connection to the main suction line, but have their suctions in the sump at the bottom of the shaft. The general arrangement of the suction piping is shown in Fig. 5.

The main pumping sets are of acid-resisting bronze, each set consisting of two 2-stage units mounted on a common base plate with space for motor in the center and cross-connected with a cross-over pipe so that the whole constitutes a 4-stage pumping set with a common

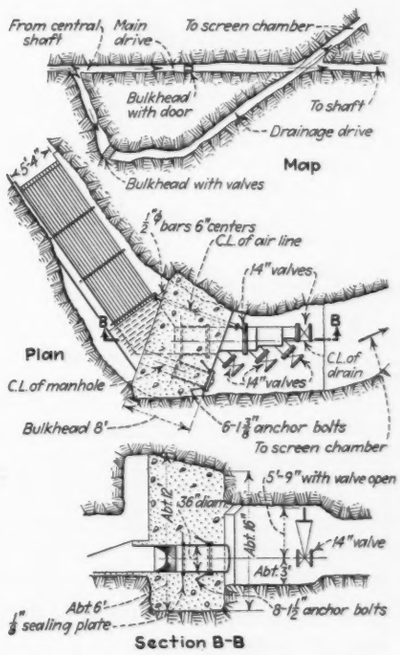


Fig. 4—General arrangement of door bulkhead

suction of 10 in. and a common discharge of 8 in. Suction connections are fitted with 10-in. gate valves and discharge connections with 10-in. check valves followed by 10-in. gate valves. The discharge from each set connects to a common discharge line running along the back of the station. This line is of cast iron and increases in diameter from 10 in. at the first pump to 24 in. where the discharges from the last three pumps join it. The line is connected to the vertical discharge column through a 24x30-in. elbow. Fig. 5 shows the general arrangement of the discharge piping.

The discharge column consists of a vertical raise lined with concrete to a circular section of 48-in. diameter, and extends from the back of the station to the 400 or main drainage level. Where it passes through the 750 level, the column is fitted with a 30-in. tee, which provides a discharge connection for the two booster units on that level. Below the tee, a 30-in. valve, with 4-in. bypass, allows for the independent operation of the 750-level pumps. The top of the column extends 4 ft. above the 400 level and is provided with a steel door. A short distance below, an offset in the column carries the water to the settling chamber of a weir, whence it discharges into the main ditch line.

Power is supplied to the pump station through four 400,000-circ.mil, 3-conductor, armored cables running from a distribution box in the Natividad hoist house down the shaft through an 8-in. cable compartment to a second distribution box at the bottom of the shaft. The distribution boxes are of the eight-way type, 5,000 volt and 500 amp., and have disconnecting links for each branch conductor, and center busbars for parallel operation of feeder circuits, thus providing an easy means of isolating cable troubles. Each cable is approximately 1,300 ft. long, and, to facilitate lowering at installation, sections of not more than 750 ft. were used. Where jointed in the cable compartment, pressure potheads of the disconnecting type were used.

From the distribution box installed at the bottom of the shaft, four cables enter the station, three of which, passing through oil circuit breakers, feed six of the main pumping units, two units to each cable. The fourth cable goes direct to a 2,300-volt transfer bus, from which the three remaining pumps are fed. The first three cables can also be connected to the transfer bus through oil disconnects, which arrangement gives flexibility of supply if a cable fault should develop in the pump station. At the 750 level, connections are provided from the shaft cables to the two booster units and to the motor for the vertical turbine pump.

Since its enlargement in the latter part of 1931, the installation has been called upon only once to deliver its full capacity. This happened when a large underground lake was encountered on the 1,000 level, Toro Mocho section. All pumps operated for six hours and were just barely able to hold the flow. The largest volume of water pumped for any length of time was 18,000 g.p.m. for five months during the first part of 1932. Since that time the flow has gradually decreased, until at the present time the load is approximately 9,500 g.p.m. This decrease is largely due to the Mahr tunnel, a five-mile drainage tunnel which is being driven to pass through the center of the Morococha district at an elevation of about 700 ft. below the 1,000 or deepest working level. [The Mahr tunnel is described and illustrated on page 414 of the October, 1933 issue of *E.&M.J.*—Ed.] Though the tunnel still lacks 7,000 ft. of reaching a point under the San Francisco shaft, it has already drained the eastern end of the district, including the San Francisco mine workings. The belief is held, however, that due to the geologic formation, considerable time will pass before the western end, from which the principal flow comes, is affected. A churn-drill hole, to connect the bottom of the Natividad shaft with the Mahr tunnel level, has therefore been proposed, the hole to be of such size as to allow for the passage of all water being pumped. When this arrangement is completed, the present pumping installation can be abandoned.

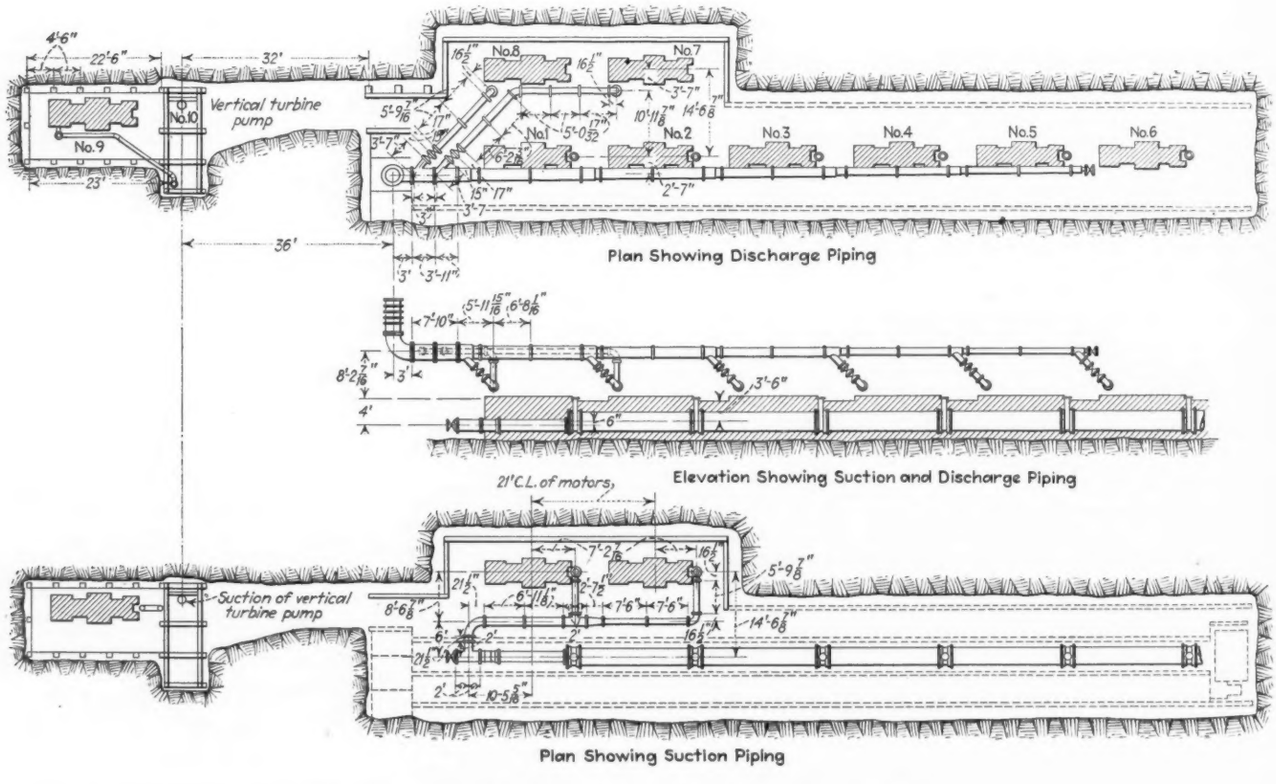


Fig. 5—General arrangement of suction and discharge piping

Silicosis: Its Causation

Mechanical and Physiological Aspects

Benjamin F. Tillson

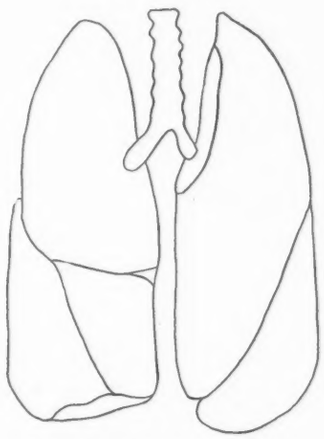
Consulting Engineer, Montclair, N. J.

CAUSATION of the industrial disease silicosis may well be considered under three aspects—the mechanical, the physiological, and the pathological. The first and second will be considered here.

Silicosis is a pathological condition commonly assumed to be caused by the lodgment of particles of free silica (quartz, flint, chert, and similar materials) within the channels and tissues of the lungs. Recently, emphasis is being given to various silicate minerals as also responsible. Dr. W. R. Jones, a geologist of Great Britain, presents strong arguments for his conclusion that the mineral sericite (a hydrous potassium-aluminum silicate of the mica family) has been more responsible for the disease called silicosis than the free silica in the rocks with which he has found it to be associated in all districts he has investigated where silicosis has resulted from mining operations. He also points out certain regions, like the Kolar district, in India, and the Scottish coal fields, where the free silica is present and no silicosis originates.

At any rate, students of the subject must deal with a mineral dust which will remain suspended in the air to such a degree as to cause its presence in the air which man inhales. Factors affecting the wind-borne transport of dusts are therefore vital to the problem. They are: Size, shape, and specific gravity of the dust particles; and the velocity, density, viscosity, adsorption, wetting power, humidity, temperature, and pressure of the transporting fluid. Various ratios such as the maximum projected area of surface per units of volume and mass, and ratios of total surface area per units of volume and mass, are important derivatives of the particle factors. A thin flake or a needle form (acicular shape) will have a slower settling rate from a horizontal stream than a spherical form of the same volume and mass.

In size, the silica dust found in the lungs has a maxium dimension varying from less than ½ micron up to a maximum of about 10 microns (or about 0.0004 in.). Some experts hold that dust less than ½ micron in size remains suspended in the expired air, and so does not lodge in the lungs. Whether strong enough evidence has been presented to warrant endorsement of such a conclusion is doubtful. Likewise, enough attention has not seemingly been given to the form factor of the dust particles when dust counts



The left lung has two lobes, the right three

have been tabulated and studied. Some observers believe that dusts in the size range of ½ to 3½ microns are the most dangerous because of two factors: percentage of surface exposed, and per cent of volume, respectively, in each intermediate size as compared with the total surface of total volume of all sizes from ½ to 10 microns when their frequency ratio in the whole amount of such dust is considered. Many persons are of the opinion that dust over 5 microns in size is not particularly dangerous.

An Oversight

Post-mortem recovery of dust particles from the lungs is often cited as evidence of the size and nature of the particles which are most dangerous, but the reasoning is not sound, for investigations have proved that silica is dissolved in the slightly alkaline fluids of the body and is then responsible for abnormal conditions of the cell structure of the lungs. Therefore, the dust which has produced the disease has probably been partly or wholly dissolved and cannot be recovered. However, the following citations hold some general interest: Dr. J. Moir, of South Africa, found that 13 per cent of 126 dust particles, from two specimens of a silicotic lung, were less than ½ micron, 36 per cent were less than 1 micron, and 60 per cent were between 1 and 3 microns, so that the median size was 1.2 microns. J. J. Bloomfield, of the U. S. Public Health Service, studied eleven different kinds of aërial industrial dusts and found only 2 per cent less than ½ micron, 21 per cent less than 1 micron, and 71 per cent between 1 and 3 microns, with practically all of the remainder less than 5 microns. Dr. C. Badham, in New South Wales, found that 67 per cent of the dust particles smaller than 8 microns which he examined were below 1½ microns in maximum dimension and that only one out of every 3,000 was 8 to 10 microns or greater in size. The authorities at Broken Hill, New South Wales, in a count of 3,500 particles in lung sections, state that for every particle having a diameter greater than 7½ microns at least 100,000 particles of a smaller diameter were present, but Dr. J. McCrae, of South Africa, found that 70 per cent of the quartz particles in the ash of silicotic lungs were less than 1 micron in size.

Number of Particles vs. Shape

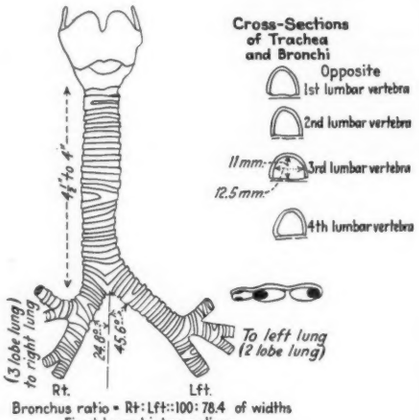
Premised on the following number of particles of silica dust per cubic centimeter of air, the specific gravity of silica being 2.64, Dr. C. Badham has computed that the respective amounts noted, depending on their shapes, will add 1 milligram of weight to 1 cubic meter of air: tetrahedral particles (triangular pyramids), 400 per mg.; spherical particles, 90 per mg.; cubical particles, 50 per mg.; and at an average figure of size-frequency ratio of 3 to 1 (three times as many of 2 micron diameter as the number of 3 micron diameter, and three times as many 1 micron as the number of 2 micron diameter) he assumes 100 particles per mg., of which 87 per cent by weight are smaller than 5½ microns.

He states that the size-frequency ratio will vary with the time given for settling before the sample is taken. In South Africa investigators found that it takes 20 min. for 5-micron particles to settle 6 ft. in quiet air; also that a period of 8 hr. was required for a 1-micron particle to settle the same distance. Dr. Jones noted that the granular silica particles settled more rapidly than the smaller acicular sericite particles, so that the silica dust in the air after blasting was almost invariably lower in percentage than that in the rock borings, and noticeably so when samples were taken three hours after blasting. He also calls attention to the fact that a 10x8x5-micron quartz particle taken from a lung has a volume equal to 800 sericite fibers 2 micron by ½ micron wide and deep, and that the quartz grain had 1,630 times as much silica as the sericite fibers. He does not suggest that no quartz enters the alveoli of the lungs, but says he has found scores of sericite fibers there for every grain of quartz.

Dust in the Lungs

Dr. Jones also states that he extracted 10 grams of dust from the lungs of a man who died from silicosis after fourteen years' exposure. Therefore, ignoring the unknown amount of dust which the lungs ejected or dissolved, the accumulation amounted to 0.0024 grams (or 240 million particles) per day. He assumes that less than 1/400 gram per day (that is, 250 million particles per day) produces fatal silicosis and states he has known of other lungs where the dust proved fatal with only 1/1,200 gram (83,300,000 particles) per day. In the former case one may assume from Dr. Badham's figures that there were only one million million particles in the lungs. The U. S. Public Health Service has recommended a dust content below 10,000,000 particles per cubic foot of air in granite working where the quartz content of the rock is 35 per cent and affirms that 6,000,000 particles per cubic foot of air is the acceptable limit where sand blasting is done with quartz sand (90 per cent or greater content). If the figure of 42 to 43 liters per minute as the ventilation of the lungs during violent working excercise be accepted, about 1½ cu.ft. of air per minute is apparently inspired, and the concentrations of dust exposure noted in the foregoing for about 3 to 3¼ years would supply more silica dust than has been found as the lethal content left in the lungs. Some writers, however, claim that only 50 per cent of the inhaled dust remains trapped in the lungs and the nasal or respiratory passages, the remainder being exhaled.

According to U. S. Public Health Service Bulletin 208, the dust count of general air in the streets of lower Manhattan, New York City, ran 3.2 millions per cubic foot of air. Although no analyses were made of that dust, the free-silica percentage was thought to be small. If the air on which the count was made were an entirely siliceous atmosphere, about four years' exposure might supply the amount of ten grams cited by Dr. Jones, and on the basis of 50 per cent elimination, eight years would provide a lethal dose. Bloomfield cites dust counts for different occupations of the granite quarrying and finishing industry varying from 17 to 144 million particles per cubic foot and having 35 per cent quartz content; and varying in quartz-grinding plants from 55 to 173 millions per cubic foot with a 99 per cent quartz content. Death would be expected from exposure for



Trachea and bronchi

54 days rather than for the years involved. Quite evidently the human system has more effective ways of disposing of such dust than it has been given credit for or else considerable time is necessary for the fatal toxic and pathological changes to be produced; or possibly (as Dr. Jones suggests) the free silica is not the important dust hazard, but some other mineral, present in minute percentages, is chiefly injurious. Certainly, further research should be carried on to explain this anomaly.

A Reminder

Students of the subject should bear in mind that such small particles of dust as are here considered are readily borne by droplets of water, so that water spraying might increase rather than reduce the dust hazard. From South Africa comes the report that a single droplet may carry over 800 particles of dust, each less than 2 microns in diameter; and in Great Britain a droplet from a grindstone left a dry deposit 2 mm. in diameter in which 4,383 particles were counted at a magnification of 900 times, and each measured less than 24 microns in maximum dimension. Asbestos fibers from the upper portions of the lungs have been known to measure 40 microns long, and so are 20 times the lengths of the usual sericite fibers which penetrate deeper.

A tabulation of the relative sizes of particles, areas, and volumes (Table I) when considered of spherical form may give a clearer idea of their relationships.

When the specific surface (ratio of surface divided by volume, and therefore equal to 3 divided by the radius) reaches a value of 10,000, adsorption to a surface becomes an important factor, according to physical chemistry, but when molecular sizes are involved with specific surface greater than 6×10^7, adsorption phenomena cannot be detected.

Respiratory Tract as a Ventilating System

I have not yet been successful in accumulating the dimensional data necessary to investigate the dust-transporting capacity of the respiratory tract as I would a ventilating system. Some interesting observations might result from such an analysis with the application of experimental data as to the air velocities necessary to transport dusts of different sizes, shapes, and specific gravities. Data must be procured as to the varying rates of inspiration instantaneously throughout its cycle and not the average rate. From them the velocities of entrance through the nostrils and at various points in the respiratory tract can be determined, and then the size of dust particles drawn into the nasal cavity. Nature has provided many dust-trapping agencies—the hairs in the nostrils, the mucus on membranes, the turbinates in the nasal cavity, sudden increases in sectional areas of the air passage to lower the velocity and drop out particles, cilia on the lining of the air ducts, and irregularities and cavities in the same. A person who breathes through the mouth is commonly supposed to be more susceptible to the accumulation of dust than one who breathes normally, through the nose, but the velocity of entrance is thereby lowered and that

Table I—Dust Particle Relationships

Type	Length of Radius	Number for Same Volume	Total Area of Surface	Surface Ratios
Small shot	1 cm.	1	12.6 sq.cm.	1
	1 mm.	10^3	126.0 sq.cm.	10
Coarse	0.1 mm.	10^6	1,260.0 sq.cm.	10^2
Suspensions	0.01 mm. = 10 microns	10^9	1.26 sq.m.	10^3
Inhaled	10 microns	10^9	1.26 sq.m.	10^3
Dusts	1 micron	10^{12}	12.60 sq.m.	10^4
Typical	0.1 micron	10^{15}	126.0 sq.m.	10^5
Colloids	0.01 micron	10^{18}	1,260 sq.m.	10^6
	0.001 micron	10^{21}	12.600 sq.m.	10^7
Molecular solutions	0.0001 micron	10^{24}	126.000 sq.m.	10^8

fact may more than compensate for the loss of some of the dust-trapping capacity of the nasal passages. Bends in the air passages would also influence the dropping out of the transported dusts.

The bronchus to the left lung has a smaller cross-section than that to the right lung (the ratio is 78.4 to 100), and the vital capacity of the left lung is less. The bronchus to the right lung deviates also less from the direction of the trachea, so why should the left lung collect the most dust, as has been reported?

Is there, under normal conditions in man, sufficient inspiration velocity to suck particles of metal grindings into the respiratory tract?

Considerable variation occurs in the breathing capacity of different persons; also, similar variations in the size of their air passages and cavities. Determination of maxima and minima would establish useful limits.

Physiological Aspect

Lungs are not simple elastic bags; they are, rather, an elastic spongework composed of thousands of little distensible air sacs (infundibula) in whose walls myriads of thin-walled air cells (alveoli) open. The windpipe (trachea) divides into two bronchi, each of which enters a lung at its root, with pulmonary blood and lymph vessels, and branches again repeatedly into finally tiny terminal bronchioles, which subdivide into a number of alveolar ducts, on which are little expansions (the atria), from which the air sacs (alveoli) open.

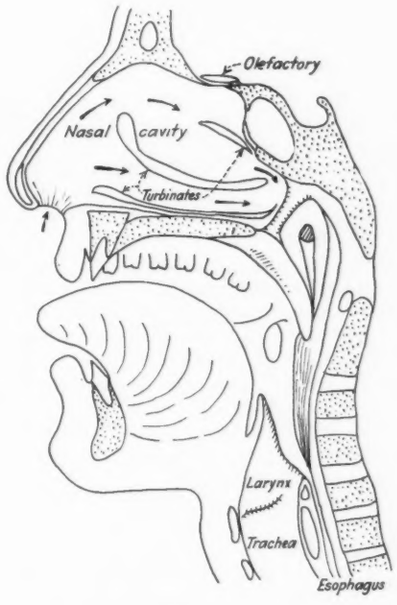
Each bronchial branch is accompanied by a branch of the pulmonary artery, which ultimately breaks up into a fine network of blood capillaries on the walls of the air sacs (alveoli). The blood from the capillaries, after oxygenation, is returned to the left side of the heart by the pulmonary veins. Strangely, the left lung is divided into two lobes and the right into three.

Each lung is enclosed in a folded-back membranous sac (the pleura) lining the interior of the chest wall. Both lungs almost fill the thoracic cavity of the chest, which is muscularly expanded for inspirations and is relaxed for expirations.

The elasticity of the lungs will support a pressure of about 30 mm. mercury-head, so at a normal atmospheric pressure of 760 mm., a force of 730 mm. pressure tends to keep the lungs expanded. Below the lungs is a vaulted fibrous muscular sheet (the diaphragm) to separate them from the abdomen. With contraction it descends about ½ in. and causes a displacement in quiet breathing at about 250 c.c. of the total of 400 to 500 c.c. The elasticity of the lungs and the chest wall plus the weight of members of the latter are largely responsible for the force of expiration against the resistance of the outflow of expired air and the resistance to displacement of the viscous blood and lymph.

The Tidal Air

In the average resting man, over 500 c.c. comes into the respiratory chambers at each ordinary quiet inspiration, and somewhat less is expelled at each expiration; so the tidal air for an adult may be assumed as about 500 c.c. It is less for children, depending upon age. Some reserve air normally remains in the lungs after an expiration and can be expelled forcibly by those practiced in doing so (with some persons only 500 to 700 c.c. extra, whereas singers and those making public addresses may expel 1,500 to 2,500 c.c. extra). But the air vesicles of the lungs cannot be totally collapsed, and they retain about 1,000 c.c. additional of residual air. A person may also become expert in the inhalation of an amount of air in excess of normal and usually about three times the tidal air; therefore 1,500 c.c. Such excess is called complemental air. To summarize, the vital capacity is the sum of tidal, complemental, and reserve air, or a total of 3,500 c.c., and the total volume of air in the fully distended respiratory system, including nasal cavity, trachea, bronchi, and bronchioles which contribute a dead space of about 140 c.c., would include the reserve air and amount to about 4,500 c.c.



Air passages of the head

The fundibula (funnel-like chambers) are the most expansible structures in the lung, and are largest where lung expansion is greatest. The average diameter of an air sac is 0.2 mm. Its volume is therefore 0.004 cu.mm. and its area of surface 0.125 sq.mm. Two hundred and fifty cells as spheres pack in a space of 1 cu.mm. and have a total surface of 31.2 sq.mm. Inasmuch as the total volume of lung tissue is about 1,617 c.c., one may calculate that if the air sacs were spherical and most closely packed. the maximum number of them would be about 400 million, with a surface of 50 sq.m.; but the volume of supporting cell structures, blood vessels and air passages must be deducted; and, again, the areal surface of each air sac is enormously increased by the projection of blood capillaries within the air sac surface; so that about three-fourths of the area consists of thin-walled capillary blood vessels. The following estimates may be quoted: Aeby, 50-56 sq.m.; von Huschke, 2,000 sq.m.; but Hufner's value of 140 sq.m. is generally taken as a mean, so that the effective adsorptive surface for oxygen and carbon dioxide exchange is about 100 sq.m.

An Illustration

If the lining of the air-sac surface could be stripped off and formed into a balloon having the same surface area of about 1,500 sq.ft., such a balloon would have a diameter of about 22 ft. A balloon of equivalent effective adsorptive surface would have a diameter of 18½ ft.

The membranes separating the blood from the alveolar air are of two layers of large irregular flattened protoplasmic cells forming a delicate film about 0.004 mm. thick, like that of a soap bubble, and through them the CO_2 gas from the blood diffuses to produce a balance between the CO_2 tension in the blood and its partial pressure in the alveolar air. The rate of inspiration rises and falls with the increase or decrease, respectively, of CO_2 tension in the blood from its normal of 40 mm. mercury-head pressure, so that an increase of 0.2 per cent in the CO_2 of alveolar air doubles man's rate of breathing and alveolar ventilation, because of the rise of tension of CO_2 in the blood to 41.6 mm. mercury-head.

So the involuntary reflex act of inspiration is initiated by the influence of CO_2 tension upon the respiratory nerve centers, which in turn stimulate muscular contractions in the diaphragm and rib muscles. When the tissues of the lungs are stretched to a definite degree, inspiration is checked by an equivalent reactive inhibitory process, so that such muscles become relaxed and expiration follows.

To stimulate deep and rapid breathing of oxygen in those overcome by asphyxiation it is customary therefore to have a carbon dioxide content of from 5 to 10 per cent mixed with the oxygen.

Although the process of oxygen transfer to the blood is a matter of dispute, many students of the subject believe that a similar diffusion exists, but in the opposite direction to that of the

CO_2. A man at rest requires about 300 c.c. of oxygen per kilogram of body weight every hour, so a man weighing 66 kg. (about 145 lb.) must pass 330 c.c. of oxygen per minute into the blood, but during violent exercise may require as much as 3,000 c.c. of oxygen per minute per kilo.

The data presented in Table II show the variations that take place in the respiratory air.

Table II—Ventilation of Lungs

	Liters per Minute	Cu.Ft. per Minute	Number of Respirations per Minute
Resting	6 to 7	0.25	13 to 14
Walking	24	0.92	14
Running	60	2.29	15
Swimming in cold water	90	3.43	..
Running up and down stairs (greatest effort of a noted swimmer)	190	7.25	Over 60

Functions of the Phagocytes

In the human system a particular group of cells, often called phagocytes, moves freely in the blood stream and lymphatic system, which are capable of ingesting (that is, enclosing within the cell as the amoeba does its food) colloidal particles, whether suspensoids or emulsoids. They have a special avidity for such acid suspensions as colloids, small particulate suspensions, fat-dust, cholesterol, bacteria, and fragmented and dying erythrocytes (red-blood corpuscles).

The red-blood corpuscles as found in human beings are disk-shaped, with diameters of about 8.8 microns and maximum thickness about 2.6 microns; and about five million are present in a cubic millimeter of healthy blood. The leucocytes (or white-blood corpuscles) are nucleated amoeba-like cells, capable of a change of shape and locomotion, which occur in the blood. In man they are mostly 10 to 12½ microns in diameter (though many are much smaller), and their normal number is 5,000 to 10,000 per cu.mm. of blood. A large proportion of the leucocytes undoubtedly originate as lymph cells in the spleen and lymphatic tissues, and pass into the blood from the thoracic duct; but they are not confined to blood and lymph, for they make their way by their own movements through most of the soft tissues of the body. Phagocyte is the name applied to such a cell which ingests (eats) a foreign body in the tissues. The whole system of such red and white cells is called the reticulo-endothelial system. They are found in the lungs, spleen, kidney, liver, bone-marrow, lymphoid tissue generally, and in the blood. They concentrate for the elimination of their waste contents in the kidney or the liver, where excretion with the bile goes to the lower intestine. So under favorable conditions, the waste products of foreign bodies are eliminated from the bowels with the fæces.

Many of the phagocytes of the lungs, however, when carrying mineral particles, get trapped in the lymph channels and nodes, and so are not eliminated. Those that are free in the blood stream are positively charged at the hydrogen ion concentration of the blood (pH 7.4) and move to the cathode in an electric field. Bacteria carry a negative charge, and so are attracted to the phagocyte and are adsorbed and then ultimately absorbed. The agglomeration of bacteria increases the efficiency of this process, as the large phagocyte cell can dispose of many bacteria with one contact. This clumping of bacteria depends upon the plasma salts being at a high enough concentration, or else bacterial absorption becomes a slow process.

The ingestion of relatively large mineral particles causes an increase in the size of the phagocyte cells, and "giant" cells are often formed, many of them polynuclear, and may include several foreign particles. The dust-laden phagocytes seek to get into the lymphatic system for elimination of the particles contained within them, but as there are no lymph vessels in the alveoli, alveolar sacs, and atria, the phagocytes must migrate along the walls of the air spaces until they reach the nearest lymphoid tissue at the distal (remote) ends of the alveolar ducts, and then they pass through lymphoid ducts to the tracheobronchial lymph nodes. Furthermore, as there are no cilia in the alveoli to wave them on, the phagocytes must propel themselves by pseudopode movements (like an amoeba) through the mucus on the walls of the aveoli and bronchioles. This amoebic action seems to be especially stimulated by their ingestion of silica.

Nature's Defence

As part of Nature's defence against the intrusion of dust in the system, a ciliated epithelium is provided as a lining of all air passages except the upper part of the nares (the nostrils), lower part of pharynx (the 4½-in. long alimentary and respiratory canal to the esophagus and trachea terminal), the bronchioles, and, finally, the pulmonary alveoli.

This epithelial structure is a layer of more or less columnar cells, on the exposed surface of each of which is a bunch of fine, tapering filaments with tubular channels opening at the tips. These cilia (hairlike processes) move in such a waving fashion as to produce a flow outward of the fluid which bathes them. They make a rapid stroke in the direction in which the action is to be effective and a slow return stroke; also, all cilia attached to any one cell or row of cells act synchronously; furthermore, any individual cell begins its effective stroke slightly later than the cell immediately external to it and slightly earlier than the cell lying internal to it. In this way a progressive wave motion is produced, to carry toward the exterior dust or other extraneous matter which becomes entangled in the mucus that is deposited in the ciliated surface by numerous glands.

Activity of the cilia is modified by almost any factor which affects protoplasmic activity, such as concentrations of oxygn, carbon dioxide, hydrogen ions, and various salts; also, increase of temperature up to a critical value causes increased activity. But, especially, the rhythm and rate are increased by mechancial loading from placing a particle on the mucus-covered tip of a cilia; and the hypothesis is advanced that the blockage of the tip opening of a blind tube increases the liquid pressure in the same and with it the increase of the flagellating activity of the cilia above their normal frequency of approximately ten waves per second.

Preventive Measures

All of these factors are of interest when considering the preventive measures which man may devise to cooperate with and stimulate natural preventive functions. For example, if dust particles had the same sign of electric charge as the phagocytes, they would repel them and not be ingested to produce toxic effects. But could elimination be provided in some other manner? A deficiency of mucus or cilia activity might be overcome by artificial means and a more rapid and complete ejection of dust particles thereby be accomplished. A suitable electric polarization of dust particles might assure their repulsion of attraction to the cilia with corresponding ejection. Establishment of a proper acidity (pH value) in the respiratory tract might be effective.

The introduction of a hydrophillic substance with an effective surface (that is, one with an area large enough to accommodate the ends of chain-type molecules which may be held end-on to it) can initiate the process of a clot formation by offering plasma-wettable surfaces to which certain blood cells (as the thigmocytes) may adhere and over which they will spread to produce their rupture and liberation of their thrombin content to react with fibrinogen and produce a clot of fibrin. Powdered glass, quartz particles, bubbles of carbon dioxide gas, and pieces of tissue provide such surfaces and can cause that serious pathology called thrombosis, so often fatal in its results. Again still another danger is created by the injection of certain mineral dusts into the systems.

The pathological aspect of the causation of silicosis will be considered in the April issue.

Soap Flotation

A Study of the Action of Depressing Gels

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A STUDY of depressing gels in soap flotation was prompted by recent articles on their formation with an acid salt and sodium silicate. In regard to the coating of quartz by such gels, Sommer follows Gerth (*Metall u. Erz,* Oct., 1930) in stating, "To suppose that the related chemical properties of quartz and silica gel should result in such an attachment may be considered reasonable" (*E.&M.J.,* Nov., 1932). Most investigators have found that the product of the addition of an acid salt to sodium silicate is a gelatinous combination of metal oxide and silica, and not simply silica gel; and no obvious reason appears for supposing that the gel is attached to the quartz "because of related chemical properties."

That quartz and the alkali feldspars are difficult to float unless their surfaces are altered by the adsorption of a metal salt or hydroxide is well known. Bartell and others have shown this adsorption to be hydrolytic—that is, silica adsorbs the basic constituent preferentially and leaves the acid in solution. Silica is then said to be "activated," because the adsorbed ions are capable of forming with oleic acid a floatable surface of insoluble base-metal soap. The adsorbed base-metal ions are also capable of forming with sodium silicate a hydrous gel which acts as depressor. This is accomplished either (1) by adding separately the base-metal salt or hydroxide, and the soluble silicate, to the flotation machine, or else (2) by adding an already prepared hydrous silicate gel. To obtain good flotation results, no attempt should be made to add the chemicals in equivalent amounts, as was done by Sommers. They should be added in such proportion as will cause all the metal ions to be taken up, which means an excess of sodium silicate. If free metal ions remain, they will react with the oleic acid, and the result will be partial activation with partial depression, and negative results.

Almost any inorganic metal salt, excluding simple alkaline salts, but including alkaline aluminates, zincates, antimonates, and plumbates, precipitates silica from solutions of soluble silicates. I made gels with fairly satisfactory results, but the precipitates were dense and cloudy, with excess metal hydroxide, and frequently an excess of one constitutent or another appeared in the flotation circuit. For example, calcium could not be used, because it was never completely taken up by the soluble silicate and always formed calcium oleate.

Discovery was made that clear, firm jellies which would allow no metal hydroxide to go free could be formed from concentrated solutions under the proper conditions with all the metals tried—namely, aluminum, barium, calcium, iron, lead, and antimony. Such jellies, when agitated with water, gave voluminous, clear, gelatinous precipitates. They made possible the use of calcium, gave consistently good results in the flotation circuit, and required the use of less metal salt.

The manner of forming these gels was as follows: Ten drops of waterglass (probably $Na_2O.3SiO_2$ to $Na_2O.4SiO_2$) was placed in a test tube and diluted to three times its volume and then neutralized with dilute acid, generally sulphuric. The metal salt solution was then added a drop at a time, and the solution maintained neutral until a clear, firm gel formed in the tube. Sometimes it was necessary to let the mixture stand several minutes before the gel formed. The amount of metal salt required was thus automatically determined for each metal used. The ratio by weight of the metal in the salt to sodium silicate varied; the ratio aluminum:waterglass=1:15, the ratio antimony:waterglass=1:40, the ratio lead:waterglass=1:40, and the ratio calcium:waterglass=1:650.

Great care must be exercised in the control of pH when making these gels; the pH should usually be very slightly on the alkaline side of neutral. A drop of La Motte indicator was always added to the gel-forming mixture in the test tube.

To test the efficiency of gels as depressors, flotation tests were conducted on the recovery of cassiterite from silicate gangue minerals in a natural ore. Most of the tests were made at pH7.2. Above pH7.2, the gels formed from heavy metals, copper, lead, antimony and quicksilver, gave good results, whereas iron, manganese, chromium, and aluminum were poor, and calcium gave no results; but below pH7.2 the lighter metal gels were satisfactory.

Inasmuch as this process is based on the use of what would generally be activating ions, data on selective flotation by activation should also serve as data on possible selective depression. Selective depression should have a broader application than selective activation in the separation of quartz, silicates low in silica such as garnet, and metal oxides such as cassiterite. (See the accompanying table.) Activation of the silica with base metal would obliterate the natural differences between those minerals, whereas depression with base metal should create differences in floatability.

Selective Flotation of Cassiterite

Natural Cassiterite-Quartz Ore (Freed of sulphides and cleaned with HCl)

pH	Gangue Depressor	Cassiterite Recovery, Per Cent	Quartz Rejection, Per Cent	Selectivity Index
7.2	Sodium Silicate	92.5	74	6.0
7.2	Al.OH.SiO_2 gel	96.0	67	7.0
7.2	Sb.Al.OH.SiO_2 gel	98.0	52	7.3
7.2	Sb.OH.SiO_2 gel	98.6	46	7.9
6.8	Ca.OH.SiO_2 gel	97.4	66	8.5

Same Ore Diluted With Garnet to Contain 40 Per Cent Garnet

pH	Gangue Depressor	Cassiterite Recovery, Per Cent	Gangue Rejection, Per Cent	Selectivity Index
7.2	Ba.OH.SiO_2 gel	80.2	59	2.4
7.2	Sb.OH.SiO_2 gel	82.5	59	2.5
7.0	Ca.OH.SiO_2 gel	95.0	49	4.3

Reagents: 0.2 lb. per ton of terpineol
0.5 to 1.0 lb. per ton of oleic acid

Novel Scraper Practice

Makes Cyanidation of Low-Grade Tailings Profitable At Randsburg

C. R. Forbes

Randsburg, Calif.

ONE of the most interesting leaching operations in the West today is that of the Randsburg Aster Gold Company, which is engaged at Randsburg, Calif., in working the tailings from milling at Yellow Aster mine.

The mine was discovered in 1893, and, according to records, milled 2,713,384 tons from 1898 to 1917, the average value per ton being $3.21. Since 1918 the mine has been worked, mostly by leasers, for higher-grade ores, which are treated in a 50-stamp mill. Tailings from present operations do not constitute a part of the dump under consideration. The aërial photograph here reproduced is part of a panorama of the Randsburg district made by Fairchild Aërial Surveys, Inc., of Los Angeles. In the upper part can be seen the glory hole where much of the Yellow Aster ore was mined. The lower part shows the tailings dump and cyanide plant. The relatively small portion of the dump already worked (approximately 75,000 tons) is strikingly shown.

Yellow Aster's old tailings dump consists of two parts, the older or higher-grade portion containing about 1,000,000 tons and the lower-grade part containing about 1,600,000 tons. The entire dump is approximately 1,800 ft. long and 1,000 ft. wide and averages about 35 ft. in depth. Extensive sampling indicated that the higher-grade portion contains $1.35 per ton in gold and the lower grade, 85c. Average gold content of the whole dump is estimated at $1.04 per ton. This may be verified by calculating the value of the ore mined as against the extraction by amalgamation used in treating it. If this extraction be assumed at 75 per cent, with a recovery of $3.21 per ton, the original ore would have contained $4.28 per ton, leaving theoretically $1.07 per ton in the tailings. This figure agrees closely with the results of sampling and with those obtained from working about 75,000 tons of tailings.

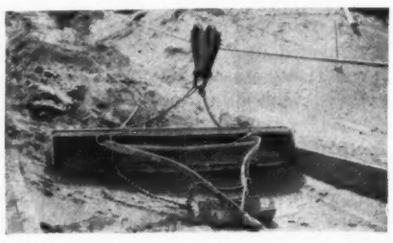
Fortunately for this leaching operation, the Yellow Aster ores consisted of a highly siliceous gangue containing free gold, a very small amount of silver, and no cyanides of any description. The ore was crushed to minus 20 mesh in the original milling operations, and very little slime was produced. The result has been to give a product ideal for cyanidation. Another favorable factor is the ideal climatic conditions

Leaching tanks, waste dump, and side drag hoist

in this part of California. The hot, arid climate of the surrounding Mojave Desert, tempered with an altitude of 3,500 ft., combines to give ideal weather for such an operation. Excessive heat does not prevail in the summer and freezing temperatures are seldom experienced in winter. The only drawback is the wind, which blows much of the time and is, of course, disagreeable. Water for leaching is obtained from the Yellow Aster Company and electric power is supplied by the Southern Sierras Power Company.

In spite of all the favorable conditions, however, the leaching of tailings so low in grade could not be accomplished by ordinary methods of handling. In 1929, George H. Wyman, Jr., sampled the dump and found the values low, but he was convinced that they could be extracted at a profit if worked efficiently. He accordingly built a small experimental plant and demonstrated that this was possible. The plant now running and the new one being built were designed by Mr. Wyman from results of experimental work on the small plant. A patent has been applied for on the method of handling and

Slack line, carrier, and scraper used for loading and unloading leaching tanks



claims covering the principal points have been allowed.

The unique features are the use of long, shallow, rectangular tanks in place of the usual cylindrical tanks, and the method of loading and unloading them with a slack line and drag scraper.

The present plant consists of three rectangular tanks of $\frac{3}{8}$-in. steel, each 100 ft. long, 14 ft. wide, and 6 ft. deep. The new plant will be exactly the same, save that four tanks will be used. Later, a fourth tank is to be added to the present plant. Construction details of these tanks are shown in the accompanying drawing. The burlap filter bottom is supported by 1-in. square strips an inch apart, resting on notched two-by-fours 12 in. apart. Four-by-four-inch ties spaced 4 ft. support 12-lb. rails 14 in. apart. Near the unloading end of the tank the rails slope upwards at 17 deg. to the top of the tank. In unloading, the scraper slides on the rails and discharges the material over the tank end. The tanks are located side by side and are fanned out slightly to make them parallel to the slack line. The distance between them at the discharge end is 12 in.

Loading and unloading are done with a 4-cu.yd. scraper operated by a three-drum electric hoist having a 75-hp. motor. This hoist is 350 ft. from the tanks. The scraper bucket, shown in an illustration, is supported by a carrier which travels on a $1\frac{1}{4}$-in. slack line. The latter is attached to a bridle line on top of the dump by a traveler sheave that permits it to be moved from side to side so that the line can be brought directly over the center of the tank to be loaded. Movement of this traveler is accomplished as follows: A half-inch rope fastened to the carrier extends around a snatch block near the end of the bridle line, and thence back around a second snatch block attached to the carrier. When the carrier is to be moved, this rope is clamped to the pull-in line. The hoist man is given the signal to pull and the carrier travels along the bridle line toward the snatch block at its end. When the carrier is in the exact position to center the slack line over a tank, the hoist man is signaled to stop, and clamps are placed on each side of the carrier to hold it in position. This centering is done very accurately with the aid of marks on the rope which enable the operator

to place the clamps at exactly the right points. The slack line and pull-in line are then lowered to permit the operator to remove the clamps holding the ropes together. The operation requires only a few minutes.

Tension on the slack line is maintained through a pair of 12-in. triple blocks at the rear of the hoist. The $\frac{5}{8}$-in. rope used with these blocks is wound on the middle drum of the hoist. One-inch rope is used for the pull-in line and $\frac{3}{4}$-in. rope for the pull-back line. The slack line is approximately 800 ft. long and the bridle line 400 ft. long.

Loading is accomplished by pulling the sand directly into the tanks with the 4-yd. bucket. Supporting the bucket on the slack line permits the loading of tanks uniformly and does not pack the material. Tanks are loaded to within 16 in. of the top, each holding approximately 160 tons. After leaching is completed the tanks are unloaded with the same scraper. The sand is pulled out over the end of the tank above a hopper, below which is a feeder that feeds directly on to a 20-in. belt conveyor, which deposits the material on a waste dump. A hopper is provided for each tank, and the feeder is moved into position opposite the tank being unloaded.

A typical operating cycle requires $2\frac{1}{2}$ hr. for loading and $2\frac{1}{2}$ hr. for unloading one tank. Three men are required: a hoist man, a signal man who also shovels lime into the tank when loading, and a man on the belt conveyor. To facilitate loading, several hundred tons are dragged down and piled directly in front of the tanks before actual loading is started. The time given is for that condition.

As the area that can be covered by the slack-line scraper is limited, a second or side-drag hoist had to be installed. This is a two-drum hoist and is used for operating an ordinary 3-yd. scraper. With the side drag pulling material directly in front of the tanks, where it can be picked up by the slack-line scraper, the tonnage available is greatly increased. Time required for side dragging varies with the distance to be pulled. It is estimated that a hoist man and a helper can drag 900 tons in 4 hr. from an average distance of 300 ft.

Leaching is conducted as follows: After a tank has been loaded with dry sand into which has been mixed 3 lb. per ton of lime, the cyanide solution, carrying 2.2 lb. of cyanide per ton of water, is pumped into the bottom of the tank through the three 2-in. pipes shown in the drawing. The tank is filled to within 6 in. of the top with the solution, which is allowed to stand for 24 hr. It is then circulated for 2 hr. and allowed to stand for 24 hr. more, after which the solution is drawn out from below and barren solution run in on top. A small quantity of lead acetate, about 1 lb. per tank, is added at this stage. From the bottom of the leaching tanks the solution goes through the filter and thence to the gold tanks, two in number, each 32 ft. long, 14 wide, and 6 deep. From here the solution is run to five ten-compartment zinc boxes and thence to the sub-tanks. The tailings are washed for two days and nights and then water is added to replace the barren solution. The whole cycle consumes four days, during which time 160 tons is treated in each of the three tanks. It is estimated that 70 per cent of the gold is recovered.

The zinc boxes are cleaned up after three tanks have been treated. The precipitate is melted in a crucible using a gasoline burner. Low-grade bullion is made and shipped to the mint. Slag from the melts is ground in a small crusher and concentrated on a laboratory-size Wilfley table. The concentrates are re-melted and the tails are saved and later sent to the smelter for treatment.

Operating costs for the month of May, 1933, are given in the table.

Yellow Aster mine and cyanide plant of Randsburg Aster Gold Company, Randsburg, Calif. Courtesy Fairchild Aerial Surveys, Inc., Los Angeles

Cost of Cyaniding Low-grade Tailings. Production 3,000 Tons

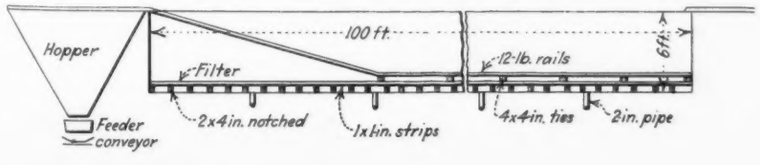
	Cost per Ton
Cyanide, 16½c. per pound	$0.023
Lime, $12 per ton	0.019
Water, $1.25 per M. gal.	0.043
Zinc shavings 18½c. per pound	0.013
Lead acetate	0.001
Labor	0.126
Power	0.026
Miscellaneous supplies	0.021
Total cost per ton excluding royalty	$0.272

Extraction 55.5c. per ton.

Time for a four-day cycle:

Unloading, stacking and loading, hr.	6½
Adding solution, hr.	3
Leaching, hr.	38½
Washing, hr.	48
Total	96

Longitudinal section of leaching tank



Trends and Developments In the Industry

Canada Developing Many New Gold Properties — Bulk of Output from Older Mines

NEW GOLD MINES are being developed and equipped with mills throughout Canada in such rapid succession that a tendency probably prevails to over-rate their importance, as compared with the few gold camps that have been operating for years. Among these new mines, however, may be found one or two that will attain in time the importance of the big producers. The Porcupine and Portland Lake camps continue to yield the bulk of Canada's gold. In both these camps the mines are in splendid condition. Sudbury, of course has also an important output of gold as a byproduct of the nickel and copper, as have also Noranda and Flin Flon.

The Hollinger mine has had one of the best years in its history of 25 years, and its ore reserves have been increased to $47,000,000 (at $20.67 per ounce). Recovery during 1933 averaged $7.99 per ton, from 1,727,102 tons milled. Ore developed at the east (Schumacher) end of the mine is above this average. Levels are now partly developed to 3,950 ft. from the Schumacher shaft, and an internal shaft has been started at this level to open the mine to 6,000 ft. Extensive exploration is under way in the west end of the mine at and above the 3,950-ft. level, where indications exist that important bodies of ore will be found in the porphyry and in the basalt—rocks that proved to be of low gold content in the upper levels. Stoping is confined at present largely to the upper levels of the mine, where an unexpected tonnage has been found in cleaning up the stopes prior to abandonment.

Lateral exploration at McIntyre, as at the other gold mines, is being conducted on the upper levels under the stimulus of the high price of gold, with good results. But the outstanding work at this mine is the internal shaft, now at a depth of 5,500 ft., which is expected to reach 7,000 ft. by the end of this year. This will give access to the lower contact of the porphyry mass, where the management hopes to find ore in volume similar to that of the adjoining Hollinger.

Dome's recovery per ton during 1933 was $11.47 (market value) from 546,500 tons milled, with operating cost of $3.73 per ton. The "new mine" below the 23d level is showing irregular bodies of ore and is being opened at two more levels; but its importance has not yet been demonstrated.

Among the smaller Porcupine mines, Coniaurum is in the best condition, with good chances of finding large bodies of ore on the lower levels. Buffalo-Ankerite continues to make a profit about equivalent to the gold "premium." Paymaster is preparing to reopen its mill. Vipond is in its last phase, cleaning up the mine after a determined but unsuccessful campaign of exploration.

Kirkland Lake continues to run a close second to Porcupine in total output, with $20,000,000 for 1933, against $21,600,000 for the latter (gold at $20.67). Lake Shore's new management instituted some months ago a clean-up of the upper levels, which has yielded a good grade of ore in such volume that ore reserves have been materially increased. Although development of new levels from a depth of 3,000 to 4,000 ft. is under way, and the new internal shaft is being sunk from the 4,000 ft. point, no stoping is being done below 2,400 ft. The average recovery during 1933 was $12.66 (without premium) from 808,917 tons milled. Operating costs were reduced during the year and averaged about $7. With a reorganized mine and mill, Lake Shore will soon be in a position to expand its output and thus definitely to take the lead among Canadian gold mines.

Teck-Hughes is also using the present opportunity to mill additional ore from the upper levels, but not on the scale of its neighbor. The lower levels now under development have not yet given results equal to the average of the mine, but the volume appears to be large and of profitable grade.

Wright-Hargreaves has increased its milling capacity to 1,000 tons a day, and the grade of ore being treated is $20 (current price). Development on levels from 3,000 to 4,000 ft. is showing ore above the average of the mine. This mine is now close to the McIntyre for third place among the gold mines of Canada, after Hollinger and Lake Shore.

Sylvanite, Toburn, Kirkland Lake Gold, and Macassa continue to operate steadily at comparatively small tonnages. Macassa is developing ore rapidly beyond the requirements of its 200-ton mill. Sylvanite is expanding its mill to 350 tons. Bidgood, to the east, is installing a 50-ton mill.

In Quebec, Rouyn still yields the bulk of the province's gold as a byproduct of copper. Noranda has its 1,000-ton addition to its concentrator in operation. Rate of gold output of the mine is close to $1,000,000 a month. Beattie is approaching the big-mine class with its mill of 50 tons' capacity. The handsome profits being made from its low-grade ore point to an early mill expansion, which is fully warranted by the volume of ore available.

In Manitoba, Flin Flon is still the leading gold producer, its output being a byproduct of copper and zinc; but San Antonio is developing rapidly into an important producer, a mill enlargement from 160 tons to 300 tons daily being under way.

Hydro-electric power is to be provided for two small gold mines in the District of Patricia by the development of a power site on the Albany River. The Hydro Electric Commission of Ontario has agreed on an initial rate of $65 per horsepower-year, Central Patricia and Pickle-Crow Mines to contract for 500 hp. apiece with 375 hp. minimum paid. Each mine will contribute $40,000 to the cost of the requisite power line. The publicly owned Hydro system assumes the risk of an early working out of these mines; but the provision of power will doubtless stimulate further prospecting in this isolated area, as has been the case at Red Lake, 100 miles to the west.

Public Hearings on Codes Postponed Until Conclusion of National Conference

THE PUBLIC conference on NRA affairs, Feb. 27-March 4, and the national code conference, March 5-8, postponed public hearings on various codes, including the copper code, a hearing on which had been scheduled for Feb. 27. In a revised schedule of forthcoming hearings issued recently by the NRA, the code is listed for hearing on March 12 before Deputy Administrator H. O. King, beginning at 10 a.m., in the auditorium of the Department of Commerce Building, Washington, D. C.

During the past month the code for the mica industry was approved and a public hearing held on the quicksilver code. Summaries of the proposed copper code, the approved mica code, and of the quicksilver hearing are appended.

Proposed Copper Code

The proposed code of fair competition for the copper industry, submitted by the United States Copper Association, claiming to represent 95 per cent of the industry, would permit regulation of copper production, by voluntary agreements by members of the industry, and the withholding of surplus stocks from the market. It would also permit allotment of volume of current production and a minimum sales price plan. These proposals are because large surplus stocks of copper exist at present in this country and further unrestricted overproduction would aggravate that condition and consequent market depression.

The code fixes a minimum workweek of 40 hr., averaged over a three months' period, and including office workers. It fixes an 8-hr. day. Emergency maintenance and repair workers may exceed these hours, but shall be paid time and one-half for overtime. Employees engaged in transporting men to and from working places or completing the handling of material in transit, hoist, power-house or pump men may not exceed 56 work-hours per week. It is provided that the 8-hr. per day limit shall not apply in the case of operations with three shifts in a 24-hr. period where at the time of change of shift it is necessary for men to work more than 8 hr. in one 24-hr. period. It is stipulated that in the case of shutdown properties or other special situations requiring modifications of these work-hour limitations, the Administrator on request of the member of the industry, and after an investigation, may make special rulings and modifications.

Minimum wages proposed are:

Eastern Wage District—Surface labor 30c. per hour. Underground labor 35c. per hour.

Southwestern Wage District — Surface labor 30c. per hour. Underground labor 38c. per hour.

Northwestern Wage District—Surface labor 35c. per hour. Underground labor 41c. per hour.

The minimum wage for office workers is $15 per week.

With regard to company towns and stores, a section of the labor provisions reads: "Employees other than maintenance or supervisory men, or those necessary to protect property, shall not be required as a condition of employment to live in houses rented from the employer. No employee shall be required, as a condition of employment, to trade at the store owned or specified by an employer."

The production and sales article is:

"The existence in the United States of large surplus stocks of copper has created a condition under which the selling price of the product of this industry has been unduly depressed. Further unrestricted overproduction can only result in further accumulations and an aggravation of the foregoing condition.

"Accordingly, for the purpose of conserving a natural resource of national importance; of cooperating in the highest possible degree in the National Recovery Program, particularly with reference to

(Continued on page 133)

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International Nickel Expands Its Smelting Capacity

Extraordinary expansion of nickel sales during recent months has warranted International Nickel in making further additions to its giant new smelter at Copper Cliff, Ont. When the new plant was erected, in 1930, the separation of copper and nickel in the ore by flotation was somewhat of an experiment, and plant for the subsequent operations was left uncompleted. This method of separating the two metals has been perfected to such a degree that four new converters for making copper matte from the copper concentrate have been ordered. As a result of this radical improvement in nickel-copper metallurgy marked economies will be obtained, compared with the older methods of separating the two metals.

The new procedure applies only to ore from the Frood mine. Smelting plants of the company are operating at more than 75 per cent of their former (1929) maximum capacity. The mines are in splendid condition to support capacity output of the smelters, which will probably be reached before the end of the year.

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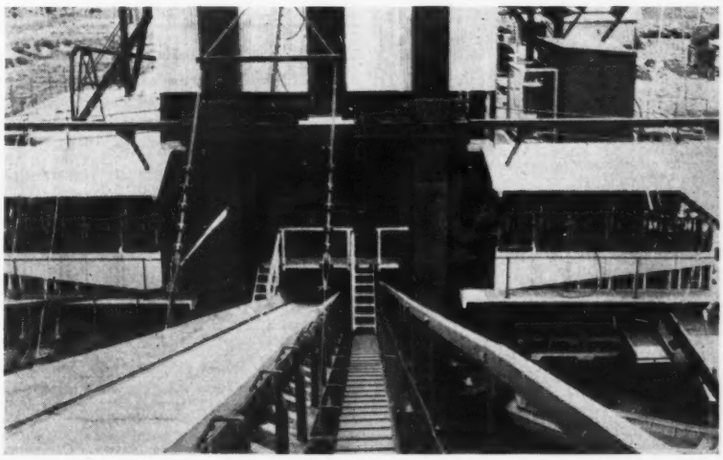
Bulolo Erecting Fourth Dredge —Uses Flotation Machines

Progress in dredging continues so encouraging at Bulolo, New Guinea, that a fourth dredge is being erected. This dredge will be constructed under much the same conditions as governed the construction of its predecessors, the last of which, dredge No. 3, was placed in operation recently. Airplane transportation, which has been described on several occasions in *Engineering and Mining Journal,* remains an essential feature. Experimental work on dredge No. 3 has indicated the success of both jigging and flotation as accessory methods of gold separation.

Through the courtesy of C. A. Banks, managing director of Bulolo Gold Dredging, and Frank W. Griffin, consulting engineer, the accompanying view of the Kraut flotation equipment on dredge No. 3 was made available for publication. Dredge No. 3 is treating more than 250,000 cu.yd. per month, the dredging depth being 45 ft. In place of the usual long riffled launders extending longitudinally along each side of the hull, the design incorporates, after the tables, Bendelari jigs, followed by a rubber-lined tube mill charged with 2½-in steel balls, a Gibson impact amalgamator, and two six-cell Kraut flotation machines. More definite application of these accessory methods will be made on dredge No. 4. The operating results will be eagerly watched for by the dredging fraternity. Increased savings indicated are of such importance that the gold-dredging industry undoubtedly will consider the application of more modern gold-separating methods in its dredges than heretofore.

Stacker end of No. 3 dredge of Bulolo Dredging Company, New Guinea, showing recent installation of two six-cell Kraut flotation machines. Use of this equipment marks new step in dredge gold-recovery methods



Higher Prices of Gold and Silver Encourage Much New Mining in the United States

MINING ACTIVITY throughout this country is apparently reacting in a most encouraging manner to the higher prices of gold and newly mined silver. One of the more recent developments of this character is the increased attention that the Appalachian deposits are receiving. A discovery in the West that is attracting considerable attention is that made at the Red Arrow property, near Mancos, Colo., which is described in detail below. Silver was given another boost on Feb. 26, when the Canadian House of Commons indorsed the world silver agreement negotiated last July at the London Economic Conference.

The Chinese government, according to a Shanghai wireless report published in the daily press on Feb. 28, on that day also ratified the international silver agreement, whereby China binds itself not to export silver resulting from demonetization of its coinage.

United States production of silver in January, as indicated in the accompanying table, totaled 2,025,000 oz., the highest output for any month since last March. Governmental purchase of newly mined silver since Dec. 21, when the price for such metal was fixed at 64½c. an ounce, totaled 1,417,710 ounces up to and including March 2, according to the U. S. Treasury.

A summary of the more important current mining operations in the various states is appended.

Utah

The mining industry in Utah is looking up. Encouraged by the rise in the prices of gold and silver, and assured by test operations of last month, a number of companies have announced that they will increase their production, and other mines, shut down for a long time, will resume operations. One of the most encouraging signs of the times was the annual report of the Silver King Coalition Mines for 1933, which showed that notwithstanding higher operating costs resulting from cooperation with the NRA, the company made a substantial net profit.

So successful have been operations of Chief Consolidated Mining in its No. 1 and Eureka Lily properties, in the Tintic district, that the company has doubled its operations by putting on an additional shift at each mine. Moreover, the company will reopen its Apex Standard property, adjoining the Eureka Standard gold mine of Tintic Standard Mining.

Another Utah company to resume work soon is Lehi Tintic Mining, in the East Tintic district, which will prospect the Gold Blossom vein, one of the most intensively mineralized properties in the district. Alta Tunnel Mining & Transportation will also resume operations in its Big Cottonwood mine, 25 miles southeast of Salt Lake.

Leasers operating the Yankee mine of American Smelting & Refining in American Fork Canyon shipped more than 500 tons of ore during the last month under the direction of Sam Stier, formerly an engineer on the A. S. & R. staff. The improvement in the prices of gold and silver has bettered the outlook of the property. Although the 500-ton output shipped during the last month is an increase of 100 tons over that for the preceding month, no attempt will be made now to augment production greatly, because of uncertain weather conditions.

A promising body of ore has been opened up in the New Park Mining property, in the East Park City district, under the direction of H. W. W. Kranmer, formerly of Denver. Mr. Kranmer, after merging the old Star of Utah, Park Bingham, and Mayflower companies, put a crew of men to work in the Star of Utah tunnel. Shortly after undertaking this work, an 18-ft. fissure was opened up 4,000 ft. from the portal. In following this fissure along its strike for a distance of 70 ft., a considerable tonnage of high-grade silver-lead ore has been exposed.

The Copperhead shaft of the Utah Central property of Engineers Exploration & Mining, in the Drum district near Delta, has reached a depth of nearly 400 ft. At the last report from E. A. Boadway, engineer in charge of operations, from 3 to 6 ft. of progress was being made daily. About 2,000 ft. west of the shaft, a winze is being put down on a shoot of gold ore. Plans of the company call for the sinking of the Copperhead shaft to a depth of 1,000 ft., where the formation will be explored.

A crosscut from the 275-ft. level of the Aurum shaft at Gold Hill has opened up the vein which in the upper levels contained a substantial amount of gold. Mined down to the 160-ft. level, the company, under the direction of Duncan MacVichie, manager, has deepened the shaft, to open up the vein at greater depth.

Development on the 750 level of the King David property, situated in the Horn Silver district, near Frisco, is entering a highly mineralized territory. Just recently the drift opened up a cave lined with gypsum, which carries some lead, silver, and gold.

A significant expansion of activities is foreshadowed by the action of Mountain City Copper stockholders at a recent special meeting in Salt Lake City when the capitalization was increased. From a prospect, a mine has been developed during the last year with an estimated tonnage of 321,000 tons of ore assured and 90,000 tons probable, having a high-grade copper content. Metal content of ore reserves is estimated by engineers, according to the report of J. O. Elton, president, as amounting to 136,965,974 lb. of copper. To develop this ore esconomically, Mr. Elton estimates that $1,500,000 must be spent for a railroad to reduce the cost of transportation; $300,000 for a 300-ton mill; $185,000 for camp facilities for 200 men, $200,000 for augmented mining plant, and $375,000 for development. The Mountain City Copper mine was recently taken over by International Smelting, which this fall completed a power line to the camp from Jarbidge. New equipment was installed and a three-compartment shaft is being sunk.

Colorado

Not so many months ago, C. H. Starr, George W. Gilmore, and their sons were out placering 9 miles east of Mancos, in the hope of washing out enough gold to buy beans and bacon. Today, they are working a mine, called the Red Arrow, which is the seventh wonder of the intermountain mining district. From a fissure in the La Plata sandstone 72 oz. of nuggets, which netted the discoverers about $1,500, 6,000 lb. of ore worth about $1 a pound, and 15 tons of ore assaying about $150 a ton in gold have been produced.

All of this came about as the result of a very unsatisfactory month's panning, which netted the four members of the party only $17. Not wanting to quit their barren diggings without another try, the elder Starr suggested that a shot or two be put in a fissure that showed iron stains near the outcrop. Panning of the fissure material gave good returns, and work contined, with the subsequent discovery of the rich ore and gold nuggets.

All the bonanza ore from the Red Arrow has come from a tunnel in the sandstone about 50 ft. above the limestone marker. Starr and Gilmore have built new cabins, snowsheds, and a blacksmith shop preparatory to drifting, raising, and sinking on the ore. Claims have been staked out for miles around the Starr property, and mining men are

World Production of Silver

(American Bureau of Metal Statistics)

In Fine Ounces

	Nov. 1933	Dec. 1933	Jan. 1934
United States	1,863,000	1,562,000	2,025,000
Canada	1,474,000	1,131,000	1,368,000
Mexico	6,033,000	5,391,000	(*f*) 6,000,000
Peru	714,000	684,000	618,000
Other America	810,000	820,000	830,000
Europe	1,140,000	1,140,000	1,200,000
Australia, refined	753,000	835,000	864,000
Other Australia and New Zealand	120,000	115,000	227,000
Burma, refined	480,000	480,000	486,000
Other Asia	645,000	660,000	700,000
South Africa	86,000	86,000	(*f*) 86,000
Other Africa	40,000	45,000	(*f*) 40,000
Total	14,158,000	12,949,000	14,444,000

For some of the countries the accounting, especially for the latest month, is preliminary and subject to revision which may be considerable. The Mexican returns, which arrive a month late, are difficult to estimate, owing to their irregularity. (*f*) Conjectural.

wondering if the East Mancos is a one-mine camp or if a really important gold-producing district has been discovered.

Because of the claim-hogging activities of some newcomers—one man having recorded and staked 85 locations—steps are being taken to form a mining district association and adopt miners' rules that will stop the blanket filing of claims. The older companies are expanding their holdings, and Consolidated Gold Fields is diamond drilling to learn more about the heavy faulting and so predict the position of orebodies more certainly than in the past. A geological description of the area, entitled "The Red Arrow Gold Discovery in the La Plata Mountains, Colorado," was issued by the U. S. Geological Survey on Feb. 28.

A. L. Beckett & Company, of Oklahoma City, Okla., is installing a sampling plant and a 200-ton flotation and amalgamation unit 6 miles west of Boulder, in Boulder County, in the heart of the telluride belt. The flowsheet consists of a series of receiving bins which will discharge ore automatically to a 15 x 24-in. Universal crusher. Following this is a secondary crushing unit consisting of a 2 x 6 ft. vibrating screen and a set of 14 x 27-in. Colorado Iron Works rolls. The ore is then conveyed to a 36-in. triple Vezin sampler and stored in a large mill bin. From here the ore is fed to a 64-in. Marcy ball mill, operating in closed circuit with a duplex Dorr classifier—Wilfley roughing tables are used ahead of 12-cell Denver Sub A flotation machines. The filtering unit consists of a Dorr thickener and an American filter. The company plans to install a cyanide unit soon.

Two active Colorado camps

Small-scale operations are in progress at five properties in the Clear Creek area, shown below: Galli Milling, Alma-Lincoln, Matti Consolidated Mining, Engineers Mining, Freeland Tunnel Transportation

Mining activities have recently increased greatly in the Mosquito Gulch section of the Alma district, shown above. London Gold Mines, American Mining and Fairplay Gold Mines are operating steadily. New enterprises include London-Butte, West London Mines, and London Mountain Gold Mines

Arizona

A number of gold properties around Ajo are being investigated, and some of them will probably be placed in operation. A. R. Gillespie, builder of the Gillespie dam, on the Gila River, has obtained a 60-day option on the Lily group of claims, one mile west of Walls Well and 20 miles east of Ajo. Seven claims comprise the group, owned by George Bradshaw and Vincent Hromadka, who have been working it since 1917. A placer mining and treatment plant of 2,000-yd. capacity has been installed at the Quitobac placers, in the Altar district of Sonora, 75 miles south of Ajo. Equipment includes a power shovel, Yuba riffle, McLeland amalgamator, and a Byron-Jackson centrifugal pump. The property embraces 2,500 acres. A Los Angeles company, of which C. A. Barker is president, is doing the work; A. A. Yurner is superintendent.

The Cudahys, nationally known meat packers, are reported to have an option on the Ben Lomond mine, 50 miles east of Ajo, and are having the workings sampled. H. H. d'Autremont and C. W. Hasselgreen, of Tucson, have undertaken to treat the tailing dump of the Sierra Pinta mine, in Sonora, for its gold content. California interests have taken over the old Morgan property, in the Quijotoa Mountains 50 miles east of Ajo. This mine has been worked for the past three years by Keith Knight and Mrs. Lotta Morgan. They have shipped several carloads of ore to El Paso. Cleaning up of the workings of the Victoria mine, 40 miles south of Ajo, in preparation for production of silver ore, has been started by Parker L. Woodman, of Phoenix.

Operation of the Tom Reed mill was started at Oatman on Feb. 16. Low-grade ore from the Tom Reed mine is being treated, as well as custom ore from other mines of the district. The mill's capacity is 300 tons per day. At Cerbat, formerly the county seat of Mohave County and situated halfway between Kingman and Chloride, B. O. Goldman, who is operating the Hawks Frontier mine, has completed the installation of a compressor and of a 30-ton capacity mill which is to be used to treat gold-silver ore from the mine by amalgamation and table concentration. Robert O. Gruwell and sons, of Los Angeles, are cleaning out old stopes and building ore bins at the Alameda mine, in the same district. At the Monitor, also at Cerbat, the workings are being cleaned out and the main tunnel will be retimbered.

About 20 miles west of Wickenburg the Sunrise gold mine is being developed by a crew of five men under C. W. Mitchell. The shaft is down 330 ft. on a vein 8 to 20 ft. wide. Levels have been cut at 60, 220, and 330 ft., and the orebody has been opened for a length of 250 ft. Ore reserves are given as 35,000 tons. A 35-ton mill is to be erected. At the Pine Grove property, near Prescott, in Yavapai County, the Weber brothers have erected and are operating a 10-ton mill consisting of stamps, an amalgamating plate, and a concentrating table. The property consists of 25 acres. The ore is contained in a contact vein, 8 to 14 in. wide, that carries gold, silver, and lead.

At the Boriana tungsten mine, near Yucca, in Mohave County, new equipment, including a compressor, an electric hoist, and a thickener for the mill, has been installed. A carload of concentrates averaging 70 per cent tungsten is being shipped every 25 days. A crew of 60 men is employed under A. J. Klamt.

California

West Mines has resumed development work at its Canada Hill mine, 2 miles southeast of Nevada City, according to word received from Orlando McCraney, president. Exploration of the St. Louis vein is the main objective of the work now in progress. The company also reports continued good developments at the Hussey mine.

A regrinding unit and agitating and thickening tanks for treating flotation concentrates have been added at the Beebe mill of Atolia Mining, at Georgetown. The company recently installed two new Hardinge-Hadsel mills.

Natomas Company, according to an announcement by Thomas McCormack, president, has purchased 600 acres of land adjacent to the Folsom field and plans to let a contract soon for a new dredge. The new dredge, which is expected to be in operation by the end of the year, will add about 4,000,000 cu.yd. a year to production.

Work has been resumed at the Mammoth mine, at Kennett, by the Mammoth Copper Mining, preliminary to mining of gold-bearing gossan which overlies the copper deposits. Erection of a reduction plant is contemplated. Charles Bray is in charge of operations.

The 70-ton milling plant of the Consolidated Metal Mines at Yucca Grove has been put on a 24-hr. basis, according to the report of Superintendent Perry Riker. Ore is being mined by the company from the Telegraph property, which has been taken over under bond and lease. A third prospect shaft is being put down.

Nevada

Miner's Gold Mining, at Midas, is sinking a winze below the tunnel level to develop the 250-ft. oreshoot mined above the tunnel. Three shifts are being employed. At the 100-ft. level, drifts will be run north and south to open up the downward extension of the ore zone.

The Comstock Lode is the scene of the greatest mining activity in Nevada. Arizona-Comstock, operating the Hale & Norcross, Savage and Chollar-Potosi, at Virginia City, has let a contract to enlarge its flotation mill from 125 tons a day to 300 tons, and will add cyanidation to treat concentrates and mill tailings. W. J. Loring is managing director and has recently been elected president.

Consolidated Chollar, Gould & Savage Mining, operating properties at Gold Hill, on the Comstock Lode, plans to replace the present ball mill with a larger one and install additional equipment at its 50-ton flotation mill, to raise the capacity of the plant to 100 tons. The company is working through the Overman shaft to the 1,100-ft. level.

George Drysdale, operating the old Hartford mine, adjoining the Justice property, below Gold Hill, will build a 50-ton cyanide mill, construction to start April 1. A large tonnage of gold ore left in the mine can be worked profitably at the present price of the metal.

At Silver City, the Dayton Consolidated has completed a 150-ton cyanide mill. The Dayton mine was reopened in 1932 by George Fuerman, of Virginia City, after being inactive and under water since 1877. The old workings, found in good condition, contain a large developed orebody in a vein 60 ft. wide which is being mined on two levels. Two other mills are treating custom ore from Comstock mines, and the Overland mine has replaced amalgamation with flotation in a ten-stamp mill.

At Como, 16 miles southeast of the Comstock, work has been resumed in the 3,500-ft. Boyle tunnel. Laterals of 1,000 ft. and 900 ft. are being driven to the Como and North Rapidan mines. Three shifts work in each heading. Broken rock is loaded by Hoar mechanical loaders and hauled in trains of ten 2-ton cars by storage-battery electric locomotive. Developed orebodies of large size will be opened at additional depths of 250 and 300 ft. Operating plans include a flotation mill of 500 tons and a cyanide unit. E. S. McCurdy is engineer in charge of the work.

Silver Butte Mining is building a 50-ton flotation mill at the Spring City silver mine, 65 miles northeast of Winnemucca, after operating a small pilot mill successfully. The property has been inactive since 1891 and is reported to have a large tonnage of ore in old mine workings and dumps.

Michigan

With copper at 8c. a pound, Calumet & Hecla is making a small profit on current production. Improvement in the company's position will be reflected in its future earnings statements. The general increase in the average price of the metal, and lower costs due to the mining of rich ores in the upper Conglomerate levels, without attendant development or construction expense, are the responsible factors.

Preparation for a resumption of mining by Quincy Mining is seen in a recent assessment call made by the company. The Quincy mine is not being operated, but it is being kept free of water. Machinery and equipment are being maintained in readiness for use when conditions warrant.

Minnesota

Repair work at the various mines on the range, mentioned last month, continues with no let-up. No definite tonnage for the season has been set, but the various steel companies will make a decision within another 30 days.

A unique CWA project has been approved, in which 20,000 will be used for test pitting the various iron-ore properties of the State, both in St. Louis and Itasca counties, to determine the actual iron-ore tonnage the State owns. Another CWA project to assist idle iron-ore property engineers is the topographic map being made of Minnesota—a project needed for many years but for which no funds were available.

World Production of Gold

(*American Bureau of Metal Statistics*)

In Fine Ounces

	Nov. 1933	Dec. 1933	Jan. 1934
United States (*a*)	256,000	270,000	235,000
Canada	241,000	248,000	226,000
Mexico	57,000	50,000	(*f*) 55,000
Colombia	33,000	25,000	(*f*) 30,000
Other South America	46,000	47,000	52,000
British India (*e*)	27,000	28,000	27,000
Japan (*e*)	38,000	(*f*) 40,000	(*f*) 40,000
Queensland	7,000	8,000	(*f*) 9,000
Western Australia	58,000	56,000	55,000
Other Australasia (*b*)	37,000	38,000	36,000
South Africa	900,000	894,000	908,000
Belgian Congo	19,000	19,000	20,000
Rhodesia	55,000	57,000	57,000
British West Africa	28,000	29,000	30,000
Russia (*e*)	(*f*) 200,000	(*f*) 200,000	(*f*) 200,000
Elsewhere (*d*)	(*f*) 95,000	(*f*) 100,000	(*f*) 110,000
Totals	2,097,000	2,109,000	2,090,000

(*a*) Includes Philippines. (*b*) Includes New Zealand and New Guinea. (*c*) Chiefly Siberia; 1933 estimated at average rate of 1932. (*d*) Includes West Indies, Central America, Europe, and Asiatic and African lands not separately reported: estimated. (*e*) Principal mines; nearly complete. (*f*) Conjectural.

A.I.M.E. Elects New Officers and Makes Awards

Results of the annual election of officers and directors of the American Institute of Mining and Metallurgical Engineers, announced on Feb. 20 in the course of the recent meeting of the organization, were as follows: Howard N. Eavenson, president and director; Louis S. Cates, vice-president and director; Karl Eilers, vice-president and director; H. A. Buehler, director; Charles B. Murray, director; Brent N. Rickard, director; George B. Waterhouse, director; William Wraith, director. At the annual dinner, held the following evening, the William Lawrence Saunders medal was awarded to Pope Yeatman "for his distinguished achievements as a mining engineer; for his vision in recognizing the value of mineral deposits and his ability in successfully developing them; for his outstanding executive ability in the management of extensive operations." Certificates of honorary membership were presented to Karl Eilers, treasurer of the Institute, and Dr. Albert Sauveur, professor of metallurgy, Harvard University. Hon. Isabella F. Greenway, Congressman from Arizona, was the guest of honor at the dinner.

The retiring president, Dr. Frederick M. Becket, in addressing the annual business meeting, expressed the opinion that in view of the changing social structure of the nation, engineers should work for a planned economy.

Code Hearings Postponed

(Continued from page 129)

employment; and of bringing about a sound and stable basis for the industry as a whole, the members of the industry, the holders of stocks of copper, and others interested may enter into voluntary agreements for the attainment of any of the following purposes; subject in each case to the approval of the Administrator and the Code Authority, which agreements shall only be binding on members parties thereto:

"1. To regulate copper production in the United States with due regard to consumptive demand, the liquidating of surplus stocks and the necessity of maintaining employment in the industry at the highest possible level.

"2. To withhold, in whole or in part, surplus stocks from the market during the present emergency period.

"3. To regulate, curtail and allot the volume of current production in such manner as shall be agreed upon by the parties participating in such regulation, curtailment or allotment.

"4. To provide a plan involving a minimum sales price with due regard to cost of production and in connection therewith a plan for the regulation and allocation of sales; and

"5. To take such other steps by negotiation and mutual consent as may be deemed necessary for the accomplishment of the purposes hereinbefore set forth."

Where there is a question whether copper is the major production from operations which also do or might produce lead, zinc, gold, silver or other materials, the question of which code shall govern is to be referred to a "coordination committee." Any member of the industry whose operations raise such a question may file with the Code Authority a statement of fact and of preference as to the code that member would prefer to be under. Also, from time to time if conditions change members shall be entitled to file such statements of fact and preference as to change of a portion of their operations from the jurisdiction of one code to that of another.

Approved Mica Code

The approved code of fair competition for the mica industry calls for a maximum 8-hr. day and 40-hr. week with the customary exceptions for emergencies and for engineers, firemen and cleaners, who may work not more than 56 hr. per week during any six-week period in any six months and who may not otherwise work more than 48 hr. per week.

The code also provides minimum hourly rates of 25c. in the South and 30c. in the North; for 27½c. in the South and 32½c. in the North in the grinding operations in the Dry Ground Mica Division; and 30c. in the South and 35c. in the North in the Importing Division and in grinding operations in the Wet Ground Mica Division.

On incomplete data it is estimated that the provisions of the code will increase employment at least 20 per cent and wages at least 30 per cent. The code became effective March 5.

Quicksilver Code Hearing

W. A. Janssen, Deputy Administrator, held a public hearing Feb. 2 on the proposed code of fair competition for the quicksilver industry. On behalf of the National Quicksilver Producers Association, W. R. Moorehead, chairman of the executive committee, presented the code without comment.

The only alterations proposed were those suggested by Dr. J. S. Gould, the labor adviser, and W. H. Edmonds, representing the Consumers Advisory Board.

The code would provide for a maximum 40-hr. week and an 8-hr. day, except in cases of emergency, when the overtime would be paid for at the rate of 1½ times the normal wage rate. The minimum wage rates would be 42½c. an hour except in the South, where it would be fixed at 30c. an hour. Clerical and other office workers, other than those in a managerial or executive capacity, receiving $35 or more a week, would be paid a minimum of $15 a week.

Dr. Gould suggested that the proposed differential for the South was too great.

Mr. Edmonds asked that price schedules be open for public inspection. The code, as submitted, provides for the distribution of the schedules among the members of the industry.

The hearing was adjourned with the understanding that it is subject to call at any time within 48 hr. by the deputy administrator.

Gold Output Up in British Columbia —Many New Projects Starting

IN AN official report recently issued, the Provincial Mineralogist estimates that the value of the mineral production of the province during the last year was $29,080,489, an increase of 2.9 per cent over the 1932 returns; but quantity production was about the same. The increase in value is mainly attributable to the higher average prices of metals during the period. The gain in gold production, however, was notable, with an increase in value of $732,519, based on the statutory price of gold. Actually, producers received in Canadian funds nearly $2,000,000 more than the recorded official figures of $4,485,780. The principal producers were the Pioneer, 84,000 oz.; Premier, 50,000 oz.; Bralorne, 26,000 oz.; Reno, 12,000 oz.; and Cariboo, 8,000 oz. Production from about 35 smaller lode gold mines was also reported. The value of the placer output was about $357,000. Production of silver (6,900,000 oz.), of copper (43,000,000 lb.), and zinc (156,000,000 lb.) was in each instance less than in 1932; but lead production (265,000,000 lb.) increased. The number of men directly engaged in the mineral industry in the province during 1933 is estimated to have been 12,000, as compared with 10,524 in 1932.

The terms on which the Premier company has acquired an option on the control of the Alexandria gold mine, at Phillips Arm, have been announced. Premier is to undertake the active management of the property, to finance development and exploration, and, if results warrant, erect a mill in return for a 60 per cent interest in the property and assets of Alexandria Gold Mines. No cash consideration is involved, as has been erroneously stated in the press. Development operations at the property are meanwhile in full swing. In the same vicinity, the development of the Enid-Julie gold property is proceeding with encouraging results, and Hercules Consolidated is reopening and equipping the old Dorotha Morton property.

Another old gold mine, the Alberni, on Alberni Canal, Vancouver Island, is also to be reopened, a company having been organized for that purpose. Financial arrangements have now been completed by Princess Royal Gold Mining to carry out the proposed development and equipment program at Surf Inlet Gold Mines.

A company known as Norgold Mines has been organized to develop the Spokane group of fourteen claims in the Atlin district. With the exception of the work done on the Engineer mine, little attention heretofore has been paid to the lode-gold possibilities of this area, which are regarded by the government district engineer as being distinctly favorable. The vein on the Spokane is a fissure which has been traced for a distance of 3,000 ft. on the surface.

In the Omineca district preparations are being made for the erection of a mill on the Columario, at Usk. Underground work is proceeding in preparation for production and comprises connecting the known oreshoots by crosscuts and raises. A main haulage tunnel has been started, and a right-of-way for an aërial tram is being surveyed. Additional power plant is also being installed.

Hydro-electric power will be available for mining purposes this summer in the Cariboo district, an English company having decided to proceed at once with a development at the falls on the Swamp River, where a first-unit plant will be established. Plans call for the generation of at least 5,000 hp. for delivery in the course of the next few months. About 30 companies are at present engaged in lode-gold development operations in the district, and in some instances encouraging results are being obtained. On Proserpine Mountain, power machinery has been installed by Cariboo Amalgamated, and tunnel exploration is in progress on three shifts. New power machinery has also been installed on the Cariboo Quartz.

In the Bridge River district, new discoveries of rich ore at both Pioneer and Bralorne continue to be made, and in the last few weeks reserves have been considerably augmented. The Pioneer plans to sink a three-compartment shaft below the 14th level in the near future.

The outlook generally in the district is extremely favorable, and indications are that at least two or three other properties will reach a productive stage this year. The Minto, particularly, has responded favorably to development.

In the Ashcroft area additions have been made to both the mill and power plant at the Vidette mine. In the Fairview district, shipments have been commenced from the Mak Siccar, and high-grade ore is being regularly shipped to Trial from the Morning Star, where, however, the early erection of a mill is planned. In the Hedley district, the Mercer interests have made the final payment on the purchase of the old Nickel Plate mine. Satisfactory results are attending development of the Maple Leaf property by Gold Mountain Mines in the same vicinity.

At the Windpass gold mine, in the Chu Chua, in the Kamloops district, the recently completed 50-ton mill is in operation.

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Rand to Raise Milling Capacity

Numerous mining groups on the Rand, according to common understanding, are shaping plans for the increase of the gold milling capacity. The price of gold has made the beneficiation of the lower-grade ores an apparent source of profit. A result of devaluation of currencies is that 2.5 dwt. ore is now of the same value to the miner that 4 dwt. ore was formerly. On the Rand it is not a case of all-out development and equipment to get these lower grade ores, but merely of extending existing drives and stopes and hoisting through shafts already in service. More power, milling capacity, and labor are about all that will be needed. Expectations are that these conditions will cause an extensive construction program to be initiated almost immediately. Primary development will go ahead also in those areas where the Rand reefs appear to extend beyond the section now being mined.

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Peace Pact Will Aid Mining in the Balkan States

The peace pact just signed by the governments of several Balkan countries is expected to cause the investment of capital to be greatly increased. This pact is a stimulant to confidence that warring activities in the Near East are at an end. The lead-zinc-silver district in Serbia, Yugoslavia, promises to develop into a most important one productively. Besides Trepca, three properties are being developed by Selection Trust and Central Mining & Investment, with most satisfactory results. Two of them will soon be ready for milling equipment. One of them, Zletovo Mines, is understood to be approaching the stage where it will be able to report over 1,000,000 tons of lead ore proved.

Courtesy Roland Blanchard and H. L. Downing

The harbor of Salamoa, in New Guinea, as seen from a near-by promontory, Hospital Hill. Salamoa is the principal seaport and airport for the New Guinea gold fields. Owing to shallow water, ships anchor in the bay and transfer their cargoes to lighters for delivery on the mainland

Geophysical Exploration and New Ventures Feature Australasian Activity

A SURVEY of the Mount Lyell field, particularly of the areas in the vicinity of the contact of the conglomerate and schist, is to be made by P. B. Nye, government geologist. Geophysical methods will be used where conditions are suitable. The Mount Lyell company is to develop the West Lyell mine, which has not been examined for 30 years, and will drive to this property from the North Lyell tunnel.

The aërial survey of 88,000 square miles in Western Australia by Western Mining Corporation began early in December. Two specially equipped De Haviland airplanes are being used. The cost is to be £100,000. Geophysical surveying will be carried out to test any promising indications.

Bululo Gold Dredging has announced that four deep boreholes across a face of 500 ft. on the original Bululo area have shown the present bottom at 22 ft. is a false one, and that the gravel exists to a depth of 75 ft. Deep drilling is proceeding. New dredges will be necessary if sufficient ground is proved.

Bismuth Products has been formed in Sydney to open up and equip the Biggenden bismuth mine, Queensland. The orebody is a massive deposit of magnetite carrying bismuth and gold. The company proposes to mine the ore selectively and to prepare a flotation concentrate, which will be shipped to Sydney for treatment.

Haven Gold Dredging has been formed to acquire and work by bucket dredging a lease of 450 acres on the Shoalhaven River, in New South Wales. A total of 5,200,000 cu. yd. has been proved.

Mount Elliott, a London company with copper properties in Queensland, is engaged in developing deep lead areas at Maryborough, Victoria. Boring has proved a length of 20 miles of deep lead with payable wash varying from 4 ft. to 42 ft. in thickness. A new operating company is to be formed.

Triton Gold Mines, Cue, W. A., which was formed to work the Reedy's Mararoa mine, has decided to begin opening up the mine by developing a level 300 ft. from the surface. For this purpose, two old prospecting shafts 1,000 ft. apart have been stripped and enlarged from the surface to a depth of 150 ft., and shaft sinking is being continued.

Hannan's Hill Amalgamated has been formed to develop the Mount Charlotte and Hannan's Hill leases on the Boulder-Kalgoorlie ore channel.

New Venture Gold Mines & Development has acquired options on the Redemption, Brilliant, Queen Extended, Flagstaff, and Lady Carmen mines, Coolgardie, and the Kapai mine, Kalgoorlie.

Gold Mines of Australia is engaged in investigating a mine at Gympie, Queensland, an alluvial area at Gilbert River, Queensland, and a mine at Fiji. At the recent annual meeting, Colin Fraser, chairman, pointed out that to find a mine of sufficient size and promise to justify development was difficult.

Mount Morgan is to increase plant capacity from 3,000 to 5,000 tons weekly. The recent re-estimate increasing ore

reserves to 2,210,000 tons has made the increase possible.

Gold Holdings, a Melbourne company, has secured an option on a property of 450 acres at Hokitiki, Westland, South Island, New Zealand. Of this area, 136 acres has been proved to contain 5,998,000 cu. yd. of gravel of good grade. A dredge to treat 12,000 cu. yd. weekly will be installed if check boring is satisfactory.

The decantation plant on the Hannans North Extended mine, Kalgoorlie, owned by Broken Hill Proprietary, has commenced operations.

Western Gold Mines, which has been diamond drilling the Reedy's Mararoa mine, at Cue, Western Australia, reports that No. 8 bore met 12 ft. of ore of good grade. This bore struck the lode at a depth of 724 ft., or 400 ft. deeper than No. 1 bore struck it.

Operations in Honduras Start Afresh —Old Properties Reopen

MINING ACTIVITY has made a fresh start in Honduras, Central America. Until recently the only mine in operation there was the well-known Juancita, near Tegucigalpa. This mine has for more than 60 years produced gold and silver. Last summer, when gold prices began to advance, W. H. Baldwin went to Honduras to look at a property named El Oro. This property belongs to Dr. Waller and associates, all residing in Honduras, and is said to contain 10,000 acres of placer. Mr. Baldwin went back to the States and returned with a mining engineer and machinery to begin operations. The work is going along fast and expectations are that within a few months production will begin.

The old Sula mine, situated in the Chamelecon valley, is about to be opened up by Pennsylvania interests. The mining rights belong to Americans living in Honduras. This mine was operated by Spanish engineers more than a hundred years ago, but it has been idle since the foreign miners were driven out in 1821.

Further down the same valley prospectors are working energetically on the re-discovery of the lost "Malo Novo" mine, that has great fame among the natives. Dense jungle covers the mountain and all signs of the famous mine have been obliterated, as it has not been worked for more than 120 years. Close by this mine is the old Santa Cruz mine, and steps are being taken to reopen it. Santa Cruz was discovered by the Spaniards, which fact is proved by old tools that have been found. In 1880 it was re-discovered by French engineers, and Société Anonime des Mines de Santa Cruz was organized. This company worked the mine about ten years, when the work stopped abruptly by a threatened war with Guatemala, as all miners were ordered to the boundary lines. Reports are that millions were taken out in that time. At the same time water was making the work in the main shaft difficult. A twenty-stamp mill was in operation. Then two English engineers, Lawrenz and Polkenhorn, purchased the mine, moved the mill, and begun a tunnel to drain the mine and at the same time to strike the vein at a much lower level. While this work went on a revolution was being started, and the operations were again stopped, and the engineers went home to England. On their return the mill had been destroyed by fire. Former employees insist that the fire was not caused by the natives with incendiary motives, but was caused by grass fires that generally are set in the dry seasons. All tools and part of the machinery were carried away; all the rest was ruined by the fire. In disgust, the mine was abandoned in 1891 to be re-discovered only a few years ago by the new owners of the land, who purchased it for ranching purposes.

From the Santa Cruz mine a canyon leads down to the Chamelecon River. A short while ago gold was found in the canyon, and 250 acres of placer ground has been obtained by the ranchers. Operation of this placer will begin some time this year with modern machinery.

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Bureau of Mines Transferred to Interior Department

President Roosevelt on Feb. 22 transmitted to Congress an Executive order transferring the Bureau of Mines from the Department of Commerce to the Department of the Interior, acting under Section 16 of the Act of March 3, 1933, which provides for reorganizations within the executive branch of the government, requires the President to investigate and determine what reorganizations are necessary to effectuate the purpose of the act, and authorizes the President to make such reorganizations by Executive order. The transfer becomes effective in 60 days unless vetoed by Congress.

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Roan Completing Second Furnace

The second reverberatory furnace being erected at Roan Antelope's smelter is expected to be finished about the middle of this year, completing the company's original construction plan. This furnace will be used as a spare while curtailment of production continues.

Mining Industry of Mexico Registers Further Gains

Cia. Fundidora Minera de Asarco will soon resume work at Matehuala, San Luis Potosi, after a shutdown of more than a year, and will re-employ about 500 men. . . .Daily output of Cia. de Inversiones del Oro, S. A., at Sombrerete, Zacatecas, has been increased to 580 tons, mostly gold and silver ore, which is being treated at the company's 600-ton flotation plant. . . . Plans are being made by Sinaloa Premier Mines to erect a 200-ton flotation plant at its Rosario, Sinaloa, properties. . . . Production of Los Reyes Mining, Nacozari, Sonora, is now 35 tons of gold-silver ores daily. . . . Twenty-two hundred tons of silver-lead-zinc ores are being handled daily by the milling plant at Potosi Mining, Chihuahua City, Chihuahua. . . . The milling plant of Cia. Mexicana Minera y Explotadora del Amparo, S. A., Guanajuato City, Guanajuato, has been increased by 40 per cent, and three adjacent mining properties are being developed.

Cusi Mexicana has purchased additional property at Cusihuirachic, Chihuahua, which places it in control of that camp, and is arranging to resume operations soon, probably during March, after being shut down since Jan. 31, 1932. As equipment has been kept in good condition, immediate production is possible, says H. C. Dudley, president of the company. . . . Cananea Consolidated Copper is employing a staff of 1,100 at Cananea, Sonora, and is producing about 1,300 tons of copper and molybdenum daily. Production of the latter ore is a recent development for Sonora. . . . About 400 metric tons of gold-silver ore are being treated daily at the 750-ton cyanide plant of the Negociacion Minera de San Rafael y Anexas, S. A., at Pachuca, Hidalgo. The company is employing 737 men in its mines and mill. . . . Forty tons of ore are being handled daily in the 250-ton concentration and flotation plant of the El Tigre Mining at El Tigre, Sonora. . . . Noche Buena Mining is producing 35 tons of gold-silver ore daily, employing 618 men, and building a small mill near Saltillo, Coahuila.

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New Rhodesian Company Formed

Dandazi Gold Mining has been registered in Southern Rhodesia and has acquired the Hope mine and Savoy claims. Developments in the adjoining Prince of Wales mine are said to have been such as to prompt the purchase of the Hope and Savoy and the provision of capital for their exploitation.

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Diamond Mines To Reopen

The Kimberley diamond mines are expected to resume operations soon, according to recent reports.

Personal Notes·Comment·Criticism

C. A. Farlow, formerly on the Miami Copper engineering staff, is leasing at Chloride, Ariz.

Sherwin F. Kelly is again in Georgia, making a geophysical examination of gold prospects.

William B. Daly, general manager of mines of the Anaconda Copper Mining Company, is in Washington, D. C.

Alvin B. Carpenter, consulting engineer, has removed his office to 1114 Pershing Square Building, Los Angeles, Calif.

R. K. Stockwell, of the Robins Conveying Belt Company, has returned to London after an extended trip to Spain and Morocco.

L. V. Mattson, vice-president of Celo Mines, Inc., a producer of kyanite and mullite at Burnsville, N. C., has been in New York for the past fortnight.

J. R. Brown, recently with the Fresnillo Company, Zacatecas, Mexico, is now superintendent of construction for San Francisco Mines of Mexico, Chihuahua, Mexico.

Hon. Charles McCrea, Minister of Mines for Toronto, was the guest of honor at a banquet on March 5 organized by the mining men and prospectors of Toronto.

C. W. Crowell, well known in the alkali and silica-sand industries, has been elected vice-president of the Rochester Germicide Company.

John D. Galloway, Provincial Government Mineralogist and one of western Canada's best-known authorities on mining and metallurgy, has resigned after twenty years' service.

Dr. Francis A. Thomson, head of the Montana School of Mines and the Montana Bureau of Mines and Geology, recently returned to Butte from a business trip to the nation's capital.

C. H. Hitchcock, of Sudbury, has been awarded the Leonard medal for his recent paper on "Diamond Drilling Practice," thereby adjudged the best paper of the year on a mining subject in Canada.

H. F. Fancy is in charge of the Casey Summit gold mine, in the District of Patricia, Ontario, for which a 50-ton mill has been ordered. Coniagas recently bought a substantial share interest in this property.

R. R. Rose, who was formerly manager of the Kingdon Mining & Smelting Company, in Ontario, has been appointed general superintendent for the Cariboo Gold Quartz Mining Company, operating near Barkerville, B. C.

Richard H. Vail, who has been examining mining properties in North Carolina and South Carolina, with headquarters at York, in the last-named State, was in New York the latter part of February.

F. B. Coyle, metallurgist of the International Nickel Company, addressed the Springfield (Mass.) Section of the American Society for Metals on Feb. 26, on the subject, "American Progress in the Use of Alloys in Cast Iron."

Milton J. Leydig, mining engineer of Butte and Missoula, has severed his connections with the Nancy Hanks Company, at Garnett, and expects to develop the Atlantic & Pacific gold group near Pony, Madison County, Mont.

Frank W. Griffin, consulting mining engineer, San Francisco, and **Max Kraut,** mining and metallurgical engineer, Pan-American Engineering Corporation, Ltd., have returned to San Francisco from a professional trip to the Bulolo gold fields, New Guinea.

Victor A. Light has resigned as assistant manager of the Tom Reed mines, at Oatman, Ariz., to join the staff of Benguet Consolidated in the Philippines. At Oatman **Jack Zwinge,** who has been mine superintendent at the Tom Reed for a number of years, has been named mine manager.

L. C. Graton addressed the February meeting of the Sudbury branch, C.I. M.&M., on deep mining. After completing a comprehensive examination of the Hollinger mine, Dr. Graton is now engaged in a similar examination of mines in the nickel district.

G. G. Dobbs is at present in London, his contract in India with the Tata Iron & Steel Company as general superintendent of iron ore mines and quarries having recently expired. During his tenure of this position Mr. Dobbs organized one of the most extensive and cheapest iron ore operations in the world.

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The recent sub-zero weather in the East has spurred one kind of mining to a remarkable degree (as visualized by Bill Spears)

C. R. Forbes, who describes on pages 126 and 127 the novel materials-handling method used in conjunction with the leaching of low-grade gold tailings at Randsburg, Calif., is the secretary-treasurer of the Randsburg Aster Gold Company, which is conducting this operation.

Dr. Karl T. Compton, chairman of President Roosevelt's Science Advisory Board, and **Dr. Robert A. Millikan** were guests of honor at a preview of an exhibition illustrating the fact that "Science and Invention Make More Jobs," held at the New York Museum of Science and Industry on Feb. 22.

Ed. Futterer, resident manager of Howey Gold Mines, is steadily reducing costs at this property, which is Canada's lowest-cost gold mine. The present operating cost is less than $2 a ton, on an 1,150-ton output. Mining methods for large copper mines in the northwestern United States are being adapted by Mr. Futterer to the needs of this mine.

OBITUARY

Dr. Thomas Clachar Brown, a former professor of geology at Columbia University; at Fitchburg, Mass.; aged 51.

Robert W. Norrington, mining engineer, died recently in Toronto, at the age of 57.

Dr. Hugo Rettich, president of the Hell Gate Mining Company, a property in the Alta district of Utah, died recently in New York City.

Thomas Carter Mitchell, until four years ago manager of the El Oro Mining Company, died recently at his home in Guadalajara, Mexico, aged 68 years.

Frank W. Graham, mining engineer, who had been identified with mining interests in Colorado since 1895, died recently in Denver, that State.

John McDowell, former superintendent of Morris mine, a property of the Oliver Iron Mining Company; at Hibbing, Minn., on Feb. 12; aged 73.

Hugh Lowden, inventor of the Lowden ore dryer, engineer and advertising manager of the Colorado Iron Works Company; in Denver, Colo.; on Feb. 5; aged 61.

George Campbell Carson, Western miner, whose claim to the patent for a side-charging reverberatory furnace was allowed by the Supreme Court of the United States after many years of litigation, died on March 3 in Los Angeles, Calif.

Frank Carroll, well known among mining and contracting men, particularly in the Western part of the country, died on Dec. 29, at Los Angeles, Calif. Mr. Carroll had been identified with Ingersoll-Rand Company for more than a quarter of a century. He was the brother of the late Fred Carroll, one time State Commissioner of Mines for Colorado.

Airplane Transportation Of Dynamite

The Editor:

Here is something I thought would be of great interest to your readers: I just saw 700 lb. of dynamite 40 per cent sticks loaded into an airplane, and this was delivered to the Cascade Mines, Inc., at its mines in King County, Wash. The powder was dropped from a moving plane from a height of 500 ft., and landed safely.

The powder was placed in sacks while in the original boxes, 50 lb. to the box and one box to the sack. A little cork was put in the bottom of each sack, and after the box of powder was placed in the sack, some cork was poured around the box. Then the sacks were tied and a red streamer was attached. The streamer is used here regularly on provisions and supplies sent in almost daily, in order that the packages can be easily seen.

This I think is the first time powder has been handled in this manner, and as it has proved satisfactory, it is well worth noting, because in many places transportation of both powder and supplies is a problem.

I asked the Cascade Mines Company people why they use airplanes, and was told that planes provide the cheapest way to transport supplies to company's mines, pending the building of a road to them.

The packing, they say, costs 20c. per case and air transportation costs from 6 to 7c. per pound. ED. WILLIAMS.

Seattle, Wash.

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Again, Tellurides

The Editor:

The work done and data submitted by Mr. W. E. Johnston constitute a long step forward, and have afforded material for a very instructive article, on a problem that is not only baffling, but almost hopelessly discouraging, to the small operative prospector with a comparatively low-grade tellurium, gold-mining property (*E.&M.J.*, August, 1933, p. 333-4).

As Mr. Blomfield says, "By implication it is rough on the operators from Kalgoorlie, Cripple Creek, and Kirkland Lake, and possibly we have been much to blame for not having written a good deal that we considered common knowledge"; and, as a matter of fact, this is only too true, as there is an almost total lack of knowledge concerning the rather low-grade gold ores with a tellurium content.

As a young man, I worked for a time in the Rosebud mill, a stamp mill in Anaconda Gulch, Cripple Creek, Colorado, and we milled ore from the Anaconda vein, as it was first opened by the surface tunnel and open cut. We took the amalgam off the plates with copper shovels, as our ore was unbelievably rich, and our tailings losses were something terrific, but it did not seem to matter to the operators or managers, as the profits were tremendous, and everything was fine.

Times, conditions, and camps change, however, and the low-grade, complex ore deposits will help augment the gold supply, and many of these old mines, in the granodiorite-argillite country, will be found to contain more or less tellurium in the vein material, and this tellurium is in a great measure responsible for the erratic fluctuations in the primary milling operations of most of the small, single-handed prospector-miner-operators in these places. When the gold content is high enough to pay, regardless of the losses, it is well; but when the losses take the most of the values, the ventures have proved failures. It is quite probable that the rich spots or pockets in these veins in this formation, and tellurium, have something to do with each other in the process of formation or deposition of the metal in the rock.

In amalgamating these ores, a portion of the gold tellurides combines with the quicksilver, especially when amalgamating in the battery, and this combination escapes over the plates in the form of a gray sand, composed of gold, tellurium, and mercury, and which will not amalgamate, and will not concentrate, but seems to float off in the muddy water. Again, in assaying or melting, with a person unacquainted with the telluric character, the tellurium content tends to carry off in fumes a good percentage of gold values from the low-grade ore.

At the Rainbow mine, near here, after the tailings from the stamp mill had weathered for several years, they were cyanided with very good results, showing that the amalgamation was poor. In the oxidized granodiorite we had the same results of a part of the gold being lost after amalgamation. At one property here we have an intrusive granite-angillite contact, causing parallel fissuring in the argillite, the fissures being filled with quartz fluorspar and pockets of free gold occurring in the quartz and rotten wall rock. At this property, the last hundred feet of crosscut tunnel is in a blue graphitic argillite, and the last vein has not yet been encountered. I do not imagine that this graphitic matter will help our recovery.

Our quartz gold here runs from $14.50 to $16 per ounce ordinarily (gold figured at $20.67). The tellurides do not show much, except in high-grade specimen rock, but in such rock they show in rough, irregular cubicle splotches, containing also considerable free gold, which is brassy and dark colored.

Impurities in our water supply through this country are also detrimental to amalgamation, and water from shafts is exceptionally bad, sulphurizing or blackening the plates. To add to these difficulties we do not have a great choice of cleaning agents, the principal ones used being lye, soda, ammonia, and occasionally we resorted to water treated with metallic sodium, used sparingly, together with frequent dressing of the plates, until the gold begins to build up, and this has been our best practice. I have no doubt that the ammonium chloride treatment printed in the *Engineering and Mining Journal*, August, 1933, at page 321, would be a wonderful addition to our practice.

A large Marcy mill is being erected at a property within a few miles of us, and we hope to learn a lot from the up-to-date data and practice in treating a large low-grade tonnage thus made available, as the ore and water conditions at the plant will be similar to our own.

GEORGE H. BODFISH.

Malheur, Oregon.

BOOK REVIEWS

A New Handbook

For Metallurgists and Chemical Engineers

CHEMICAL ENGINEERS' HANDBOOK. *John H. Perry, Ph.D., Editor-in-chief, and W. S. Calcott, Ch. E., Assistant Editor. McGraw-Hill Book Company, Inc., New York. Pp. 2609. Price $9.*

Although written primarily for chemical engineers, as one of a series of text-and-reference books in chemical engineering, this volume contains a great deal of matter of interest and use to metallurgical engineers. The work is compiled in 30 sections contributed by more than 60 specialists. In authority it ranks with the well-known handbooks in other branches of engineering. Of particular interest to metallurgists are the sections on drying, mechanical separation, crushing, grinding and pulverizing, measurement and control of process variables, materials of construction, movement and storage of materials, electrochemistry, accounting and cost finding, and patents and patent law. The last is a notable statement of special service to all groups of engineers concerned with patents. The volume is particularly well arranged for ready reference. In addition to a general index there are tables of contents and references for each of the 30 thumb-tabbed sections.

A Miniature Flotation Cell

In Volume II, No. 1, of the Technology Reports of the Tôhoku Imperial University, Sendai, Japan, published last year by the university, there appears an article entitled "On the Flotation Research With a Miniature Machine," by Takanori Mayeda. This article deals with the design of a new flotation machine and its use in the determination of fundamental data. The general arrangement of the apparatus is shown in Fig. 1 and the detail of the glass cell in Fig. 2.

It will be recalled that three miniature flotation machines, all on mechanically agitated lines, have been proposed; namely, that by Gates and Jacobsen described in the Bulletin No. 16 of the University of Utah, page 38, 1926; that designed at the University of Utah and described by H. D. Keiser in *Engineering and Mining Journal*, Vol. 126, page 504, 1929; and that recently placed on the market under the sponsorship of M. S. Hansen, also described in a recent issue of the *Engineering and Mining Journal*.

The Gates and Jacobsen machine was made of sheet iron painted with aluminum paint. Objections to it have been numerous from a chemical standpoint, although it seems to be mechanically satisfactory.

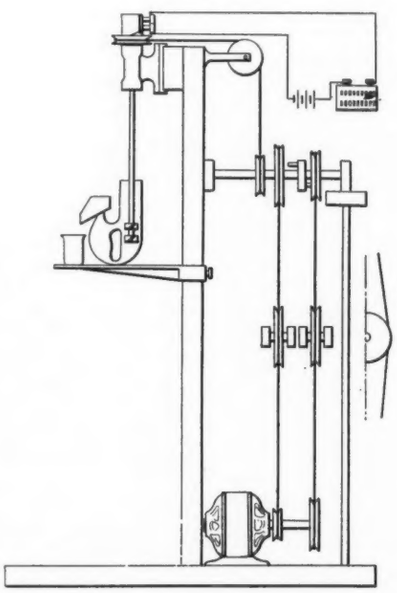
The machine devised by C. B. Haynes and the present reviewer, and described by Keiser, was made of celluloid with an impeller coated with celluloid so as to prevent reaction of the pulp with the material of the machine. It has proved very satisfactory in a number of laboratories. The Hansen machine is of the same type except that it is made of porcelain, which is presumably even less likely to react with flotation pulps than celluloid.

The Mayeda machine is made of glass and features an extremely small aperture through which the bubble column is to discharge through the overflow lip. This is claimed by the inventor to minimize the possibilities of error due to material remaining as froth on top of the pulp at the end of a flotation operation.

Numerous experiments were conducted by Mr. Mayeda. These experiments proved that the machine is satisfactory, but they do not convey information that was not known already. The interest of the article for the average American student will therefore be in connection with the new miniature cell rather than with the experimental data.

A. M. GAUDIN.

Fig. 1—General arrangement of apparatus



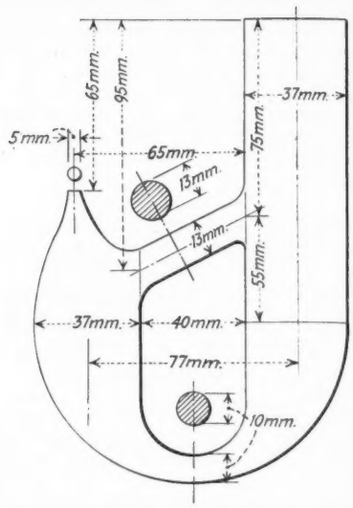


Fig. 2—Details of miniature flotation machine

Arc Welding

PROCEDURE HANDBOOK OF ARC WELDING, DESIGN AND PRACTICE. *Lincoln Electric Company, Cleveland, Ohio. Pp. 434. Price $1.50, domestic postage prepaid. Foreign postage 35c.*

Basic information on arc welding in its present status has been brought together so as to afford a convenient reference on the subject. Many users of the process have cooperated to supply the data and illustrations. The contents are indicated by the chapter headings: Welding Methods and Equipment, pp. 3-16; Technique of Welding, pp. 17-44; Procedures, Speeds, and Costs for Welding Mild Steel, pp. 45-90; Structure and Properties of Weld Metal, pp. 91-98; Weldability of Metals, pp. 99-126; Designing for Arc-Welded Structures, pp. 229-318; Typical Applications of Arc Welding in Manufacturing, Construction, and Maintenance, pp. 319-412.

Standards

BOOK OF A.S.T.M. STANDARDS, 1933. *American Society for Testing Materials, Philadelphia, Pa. Part I, Metals. Pp. 1001. Price $7.50. Part II, Non-metallic Materials, Pp. 1298. Price $7.50. Price for two volumes $14.*

These volumes contain 466 standards now in effect. Part I includes 185 of these, 104 relating specifically to ferrous metals, 70 to non-ferrous, and 11 to metallic materials in general. The standards comprise specifications (as, for ex-

ample, of Lake and electrolytic copper (wirebars, slabs, billets), methods of test and analysis (as, for instance, of Brinell hardness testing and for the battery assay of copper), as well as definitions and recommended practices covering materials of engineering and the allied testing field (as in the rules governing the preparation of micrographs of metals and alloys, including recommended practice for photography as applied to metallography). The book is issued every three years, the previous edition being here brought up to date.

New Era

THE POWER AGE. *By Walter N. Polakov. Covici, Friede Inc., New York. Pp. 247. Price, $2.*

Does the period of economic distress through which we are now struggling represent the regular cyclic recurrence of depression, or are we experiencing an upheaval caused by fundamental changes in the economic structure of our modern civilization? The author entertains no doubt in this respect; we are standing on the threshold of a new era, and a return to the conditions of the past decade is not possible. What he terms the Machine Age, the age in which the machine was nothing but a glorified tool, is behind us, and we are finding ourselves in the Power Age, the era of mass production, in which the machine has become self-contained and largely automatic.

With this distinction between the Power Age and the Machine Age an entirely new thought is injected in the discussion, the development of which reveals many problems in regard to management and industrial planning. To apply old methods of management to the new conditions would be as incongruous as making an inexperienced teamster drive a high-powered car. During the past years we have been trying to apply the principle of mass production without mass consumption, and the system has jammed.

Although the author does not minimize the difficulties involved, he takes no pessimistic view of the future, but appears to feel reasonably sure that the ultimate outcome will be a great improvement in the living conditions of the masses. It is refreshing, in these days of dire prophesying regarding the ever-increasing lack of opportunity for useful occupation, to find such a statement as the following, "Our disease is not technological unemployment, but its exact opposite—the unemployment of technology." In offering his remedies he is mainly concerned about the first step, that of facing and analyzing facts to get a correct foundation for a new plan. For this purpose engineering experience evolved during the early days of mass production a mechanism of graphic coordination, and control of planned activities are required.

Petrology and Mineralogy

Two Books for Determinative Work

DETERMINATION OF THE FELDSPARS IN THIN-SECTIONS. *Dr. Karl Chudoba. Translated by W. Q. Kennedy, D.Sc. London: Thomas Murby & Company.*

This excellent translation of Chudoba's "Die Feldspate und ihre praktische Bestimmung" was published with the hope of propagating the use of the "determinative methods of the Vienna school among English petrologists and students." Dr. Kennedy is to be congratulated on his translation, which preserves the style and thought of the original very well indeed.

The book is divided into five parts. The first three parts are devoted to a brief discussion of the composition of the feldspars, their crystal morphology and their optical properties. There is nothing new in this discussion. The fourth section deals with the well-known methods for the microscopic determination of the alkali feldspars, and the first part of the fifth section deals in a similar manner with the determination of the plagioclase feldspars. These methods are perfectly familiar to all students of petrography. Dr. Chudoba has perhaps been happy in describing the already familiar procedures concisely and clearly.

The second part of the fifth section introduces the use of the Fedorow universal stage. The description of the instrument and the requisite preliminary adjustments is much too brief. This part of the book could have been expanded to advantage. Considerable attention is devoted to the zonal method of the determinations of the feldspars by means of this instrument. To become familiar with the method and the use of the instrument, however, the student would require a microscope fitted with the Fedorow stage, and would have to follow the descriptions step by step.

For those who find difficulty in reading German this little book will prove helpful to a better understanding of the use of the Fedorow stage for feldspar determinations. R. J. COLONY.

THIN-SECTION MINERALOGY. *By Rogers and Kerr. McGraw-Hill Book Company, Inc. New York. Pp. 311; 261 illustrations. Price $3.*

This new textbook in the field of optical mineralogy, though perhaps a little brief in the discussion of certain optical properties, has the distinct advantage of giving the student optical theory, description of minerals, and determinative tables in a single reasonably priced volume.

A group of 38 line drawings of aggregates and structures, with mineral examples listed for each; a number of photographs of typical minerals in thin-section; and a double-page colored birefringence chart are among the special features. The birefringence chart is inserted at the place where the table of birefringence is given, and though it is not as large as the charts accompanying other textbooks in this field, it is more convenient than a folded chart in a pocket.

The text material dealing with mineral optics is condensed, but it is readily understandable when studied with reference to the numerous line drawings. The discussion of biaxial interference figures might well have been more complete. Additional sketches and remarks regarding the appearance of sections having orientations other than those given would have helped to clarify a not too simple phase of mineral optics.

The junior author has written Part I, which starts with a summary of the technique of preparing thin-sections as developed in the laboratories of Columbia University by Paul H. Bird. The properties of light, refraction, plane and convergent polarized light and color, form or aggregation are chapter topics.

Part II, compiled by the senior author, includes descriptions of the optical properties of approximately 130 minerals. Complete descriptions include chemical formula, color, form, cleavage, relief, birefringence, extinction, orientation, twinning, interference figure, distinguishing features, alteration, and occurrence.

Twelve mineral tables contributed by the junior author are arranged for the convenient determination of minerals. The various tables separate the minerals into the following groups: opaque, colored, shape or form, cleavage, index of refraction, isotropic, double refraction, uniaxial positive, uniaxial negative, biaxial positive, biaxial negative, and axial angle.

The authors, in giving a concise, elementary treatment of mineral optics, a brief but adequate description of the more common minerals seen in thin-section, and compact simple tables, have produced a book well adapted for the beginner in the study of optical mineralogy. DONALD M. FRASER.

Geophysics

APPLIED GEOPHYSICS IN THE SEARCH FOR MINERALS. *By A. S. Eve and D. A. Keys. Second Edition. Illus.; pp. 290. Cambridge: at the University Press; New York: The Macmillan Company. Price $4.25.*

It is gratifying to learn that popular interest in geophysics is such as to warrant a second edition so soon of this

readable work. For a book already so well known it seems hardly necessary to outline the plan of treatment, yet the issuance of this new edition shows it is reaching an ever-growing circle of readers. For those to whom it is not known, the work can be commended as an easy but sound introduction to the science and art of geophysics, as viewed from the standpoint of the engineer or geologist who is contemplating the possible application of these methods in solving some engineering or geological problem. The fundamentals of the magnetic, electrical, gravitational, and seismic methods are simply explained, and the reader is led by easy stages to a comprehension of the mathematical principles underlying both the instruments used and their applications in the field. Radioactive and geothermal methods also receive some attention. The authors make their work practical by referring to numerous actual field surveys.

For those acquainted with the first edition, it may be said that the new one is some forty pages longer, the additions being principally in the magnetic and electric methods. For example, some discussion of the calibration of magnetic variometers has been added, together with descriptions of illustrative "surveys" carried out over bar magnets. Magnetic depth determinations on dikes are also described. In the electrical section, some pages have been added dealing with surveys in boreholes, and additional examples of resistivity surveys have been included. Potential drop ratio methods are here considered, and in the last chapter mention is made of some bona-fide "treasure finders" and buried-pipe tracers. The appendices have been increased from two to four, one new one dealing with the magnetic attraction of vertical dikes and the other with seismic propagation paths. The appendices, it may be remarked, are for the mathematically minded.

SHERWIN F. KELLY.

Gutenberg

HANDBUCH DER GEOPHYSIK. *Edited by B. Gutenberg. Band 1, Lieferung 2. J. Bartels: "Gezeitenkraefte." F. Hopfner: "Die Gezeiten der festen Erdkruste." M. Milankovitch: "Drehbewegungen der Erde," and M. Milankovitch: "Saekulare Polverlagerungen." Berlin, Gebrueder Borntraeger. Pp. 191, 35 figs. Price, this volume only, 36 Rm. Subscription price, 24 Rm.*

This volume of the *Handbuch* deals with the tides of the ocean and of the earth, the movement of the earth in space, and migrations of the earth's poles. In the first section, Bartels gives a discussion of the calculation of tidal forces and the harmonic analysis of tidal observations based largely upon methods devised by Doodson, Darwin, and Boergen. The second section, by Hopfner, deals with bodily tides and conclusions to be derived in regard to the elastic constitution of the earth from Zoellner pendulum and similar observations.

The remaining two-thirds are written by Milankovitch. His first section treats of the earth movement in space in general and with the phenomena of precession and nutation in particular. The second discusses pole migrations and the mathematics of the earth's rotation for the assumed cases of a liquid earth, of gradually changing axes of inertia, and of an isostatically arranged body.

Unfortunately, the limitations of space do not permit consideration of the details of this excellent book. Upon one thing, however, the reviewer wishes to comment: It is Milankovitch's masterful presentation of a highly intricate subject which makes his work very fascinating for those who want to become acquainted with the mathematical foundation for many (often altogether too extravagent!) theories of historical geology.

C. A. HEILAND.

Ore Deposition

HISTORY OF THE THEORY OF ORE DEPOSITS. *By Thomas Crook. London, Thomas Murby & Company. Pp. 163. Price 10/6.*

In its reaction to the subject-matter of this book the mining profession is probably divisible into three camps. The first is represented by the mining engineer, who, having blocked out an orebody, called in his geological friends to see if there was any theoretic reason why ore should not be present; the second is a small group of littérateurs and antiquarians, of whom T. A. Rickard and H. C. Hoover are the flower; and finally that large body concerned with mining development, exploration, and teaching who have an intelligent and practical interest in ore genesis. To the latter two groups this book should appeal scarcely less than to the economic geologist and petrologist.

The speculations of the ancients and the observations of post-medieval writers on the much controverted subject of the origin of ore deposits are recorded in this book by succinct quotations, interestingly interpreted and correlated by the author. To some readers the original German and French of many writers will be a stumbling block. A corollary to the cyclic recurrence of fashionable theories thus revealed is the striking difficulty of proposing new classifications of ore deposits which are not to some extent resurrections of one of the myriads already proposed.

Fire and water, the rival elements of the old philosophers, were championed by the Plutonists and Neptunists respectively in the eighteenth century, and in the scientific period they find their representatives in the igneous versus the aqueous schools of opinions. Taking up the thread of the argument at the beginning of the present century, the origin of some ores by direct igneous action (magmatic segregations) had been demonstrated by J. H. L. Vogt, of Norway, and generally acknowledged; the controversy hinged largely around the relative importance of meteoric and magmatic waters as sources of mineral deposits. The ablest protagonist of the meteoric water theory in this country was Van Hise, with his scheme of descending and ascending lateral-secreting solutions.

The current ascendency of the igneous hydrothermalist school began in 1901 with an epochal series of papers by Kemp, Vogt, Lindgren, and others at the Richmond meeting of the American Institute of Mining Engineers, which placed on a firm basis the recognition of a broad group of deposits formed as after effects of igneous action. To the American engineer, schooled largely on the texts of Lindgren and Emmons on this subject, the reactionary insistence in the book under review of the "overwhelmingly predominant" part played by meteoric waters in ore deposition will come as a distinct jolt; e.g., "Exogene processes account for not less than 85 or 90 per cent of the present annual value of the world's mineral output." With the historic background in mind, however, one may wonder if the igneous hydrothermalists may not be reaching their zenith in recently taking into their fold deposits remote from any igneous source (apomagmatic or telethermal). The author's provocative overemphasis may well be a purposeful attack on what has danger of becoming a ruling theory; the account of the development of ideas is readable, notwithstanding his dissent with present apparent trends.

The final chapter of the book is entitled "The Rise of Petrology." By tracing the progress of that science up to the middle of the nineteenth century, it is shown that the earlier petrologists entertained broader views of the scope of their subject. "Since that time petrologists have settled down to the study of the microscopical, physical, and chemical aspects of silicate and sedimentary rocks, with no interest in metalliferous-vein and other ore deposits as far as petrology goes." Though this criticism may be valid in Europe, it loses cogency in this country, where, in part by force of economic circumstances, there is a happy union of economic geology and petrology, as witness the sections devoted to petrology in the Lindgren Volume on "Ore Deposits of the Western States" and to ore deposits in Grout's "Petrography and Petrology."

The author has done a service to students of ore genesis, on whose shelves this book should have a place despite (or because of) its partisan viewpoint.

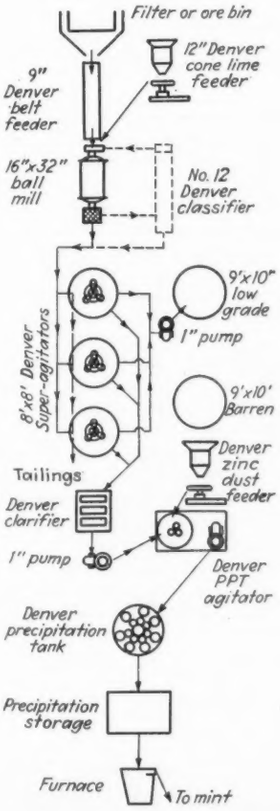
A. K. SNELGROVE.

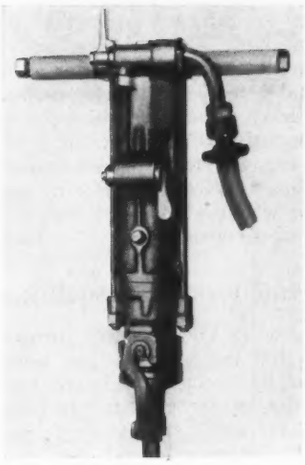
INDUSTRIAL PROGRESS

Cyaniding Concentrates at Small Properties

In view of the situation in Canada, where most gold mining properties are treating their table and flotation concentrates by cyanidation, the Denver Equipment Company, Denver, Colo., has designed a cyanide plant particularly adapted to treating small tonnages. In particular, it has standardized on one able to treat 1 to 5 tons of concentrate a day by cyanidation. A flowsheet is shown herewith. As will be noted, this calls for a small regrind mill and accurate reagent feeders for lime and cyanide as well as for zinc dust; also the company's Super-agitators. The latter units are particularly adapted for treating concentrate, because of the intimate aëration given the cyanide gold-bearing pulp by them. After this agitation, the gold-bearing solution is decanted from the slimes and is then clarified and precipitated in the ordinary way by means of zinc dust.

Flowsheet for cyanide concentrate-retreatment plant of 1 to 5 tons' daily capacity





New Sinker Drill

A new rock drill intended particularly for heavy sinking work in hard ground, as well as for long-hole quarry drilling and for similar duty, has been developed by the Chicago Pneumatic Tool Company, New York. It is known as the Model CP-52, and is made both as a wet and as a dry machine. Net weight of the dry machine is 80 lb. and of the wet machine, 83 lb. It has a 3-in.-diameter cylinder and an over-all length (with retainer) of 24¾ in. It takes a ¾-in. air hose, ½-in. water hose, and steel of 1-in. hex. by 4½-in. shank. Claims made for the new drill are to the effect that it can be handled more easily and faster than other machines of its weight and type; and the valve acts positively and gives a powerful rotation. It has an exhaust choke for emergency blowing. This is said to be able to blow holes clean down to 25 ft. Several other chucks are available in addition to the one indicated by the size of steel mentioned.

General Utility Crane

A convertible crane having a wide range of uses as well as unusual transporting speeds, capacity, and stability, has been introduced by the Harnischfeger Corporation. It can be used for handling material and equipment and is convertible as a clamshell crane, dragline scraper, or for tractor service. It has three transporting speeds, namely, 1.3, 2.6, and 5.2 miles per hour. In weight tests, without a counterweight, it has picked up 5,200 lb. and traveled with it at the last-named speed. With a detachable stiffleg under the boom, it will lift 35,000 lb.

Alloy Steels in Switches and Crossovers

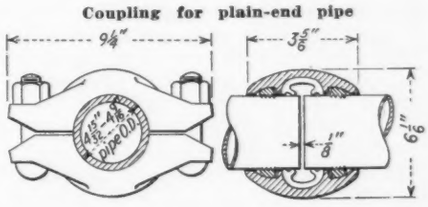
Plain carbon steel in switches and crossovers for mine tracks has proved decidedly unsatisfactory, in European practice, according to the International Nickel's *Nickel Steel Topics.* Flattening of the frogs, deepening of the grooves, and general deformation from wear are common, with the result that cars are derailed and the whole transportation system is slowed up. For a long time 12 to 14 per cent manganese steel was the only cast alloy steel used to overcome these difficulties. This steel has a remarkable wear resistance, but machining is difficult and in many cases it is necessary to resort to grinding; in addition, it is hard to weld and has a relatively low elastic limit. Hence breakage from fatigue is not uncommon. The nickel-chromium-molybdenum steel, on the contrary, besides having a high resistance to abrasion, is weldable, machinable, and has a high elastic limit. After air quenching and drawing, its mechanical characteristics are as follows (depending on the drawing temperatures):

Ultimate strength 125,000-240,000 lb. per sq.in.; elastic limit 105,000-200,000 lb. per sq.in.; elongation 6-16 per cent; Brinell hardness 275-550. Thousands of frogs made of this steel have been used the last six years under very heavy traffic conditions, and their record is highly satisfactory.

Another Pipe Coupling

A simple pipe coupling which it is said can be readily assembled by the cheapest sort of labor is shown in a cut. It is made by the Champion Machine & Forging Company, Cleveland, Ohio. It is called the company's "Plain End" coupler. With its use, the joint can be broken and made again any number of times without impairing the coupling's efficiency. It was developed to facilitate laying of pipe lines with straight plain-end pipe which does not have to be subjected to an extra finishing operation, such as grooving or upsetting the ends,

Coupling for plain-end pipe



threading or beveling. At the same time, it is said to provide strength in tension sufficient to meet all strains met in the line. The coupling has five parts: two half couplings which contain the gripping device, one gasket with metal-protected sections, and two bolts. These are of drop-forged special steel, the gripping rings being heat-treated as well, to produce a hard, tough section, and assembled into the half couplings so as to become integral with the coupling itself and avoid being lost. The coupling has been tested up to 4,000 lb. per square inch on commercial pipe without extra preparation on the ends.

New Diesel Locomotive

A 12-ton 0-4-0 diesel locomotive with mechanical drive has recently been shipped to Puerto Rico by Whitcomb Locomotive Company, Rochelle, Ill. It will start 390 trailing tons on the level with sanded rail, or 290 tons with clear dry rail, and will haul 324 trailing tons up to 10.82 m.p.h. and 190 tons up to 16.87 m.p.h. It can be built to any track gage from 30 in. up. Power is furnished by a 6-cylinder, 4⅞x6 in. full diesel engine, rated conservatively at 85 hp. net at 1,200 r.p.m.

Whipcord Transmission Belt Has No Inelastic Stretch

A new transmission belt of endless-wound whipcord construction that has no inelastic stretch has been developed by Manhattan Rubber Manufacturing division of Raybestos-Manhattan, Inc., Passaic, N. J. This is known as the Condor Whipcord belt and is the product of research made in quest of high-speed high-tension drives which are said to require almost invariably an endless belt. The new belt is the continuous endless-wound type. Its single-layer cord section is equal to six duck plies in strength and is many times more flexible.

An Improved Valve

A new globe valve that can be closed tightly and easily kept so has been introduced by Jenkins Bros. in its so-called 200-lb. "bronze regrind-renew" valve. It is easy to close tightly because of the radial-faced seating surface of the disk, which is said to provide perfect seating. With this improved seating the diameter of the disk is said to be scientifically correct in relation to the seat, so that the valve can readily be kept tightly closed. The disk does not extend beyond the seat contact surface, as a result of which repeated regrinding cannot cut a shoulder or groove into it.

For jobs that require throttling, or where conditions are unusually severe, this valve may be had in a plug-seated type.

Timer for Welding Machine

An electronic timer, so-called Type HA, which measures out a pre-set length of time and closes or opens its contacts for that time after the initiating impulse has been given from a pushbutton, foot treadle, or cam-operated switch, has been developed by Westinghouse. The device is used for such operations as the timing of spot and projection welder current flow, X-ray timing, and other similar applications requiring an easily adjustable and accurately maintained time delay. The time measured out is continuously adjustable from 1/10 sec. to 45 sec. It can be applied to any spot or projection welding machine now in service which is equipped with a magnetic main contactor.

Electric Furnace for Small Runs

A new rocking electric furnace, of 25 to 100 lb. capacity, has been announced by the Detroit Electric Furnace Company, of Detroit. It has been designed for either production or experimental melting of small lot runs of metals. Except for size, the furnace is a faithful reproduction of the larger rocking electric furnaces and, according to the manufacturer, will provide speed, economy, and analysis control. The furnace is completely equipped with transformer, control panel, switches, meters, and rocking mechanism. It has a nominal electrical rating of 20 kw. and may be connected to any industrial power supply.

Protection Against Burning Out

A motor which cannot burn out has been announced by the Lincoln Electric Company, Cleveland. The protective device is built into the windings. Should the motor be stalled through overloading, become excessively hot due to poor ventilation, or run on single phase, the device shuts off the current. A.C. induction motors thus protected are built in sizes from ½ to 30 hp. for either two or three phase and standard commercial cycles and voltages.

INDUSTRIAL NOTES

Low, Kelly & Zuschlag has been incorporated under the name of Combined Geophysical Methods, Inc., with offices at 50 East 42nd St., New York.

Robins Conveying Belt Co., New York, has acquired the ore and coal handling business of the Mead-Morrison Manufacturing Co. of Boston, to be operated henceforth as the Mead-Morrison division of the Robins company. The consolidation gives the latter company a complete line of material-handling machinery. The Mead-Morrison office in New York has been closed, and its personnel moved to the Robins offices at 15 Park Row, New York.

Ingersoll-Rand Company has acquired the turbo-blower business of General Electric Company and will consolidate it with its own turbo-blower department. It has long been a manufacturer of blowers of medium and large capacities, for pressures ranging up to 100 lb. General Electric has specialized in both single- and multi-stage units for a variety of services in low and medium pressures. Ingersoll-Rand also secures an exclusive license under the various General Electric patents. The manufacturing equipment previously employed by General Electric is being moved to Ingersoll-Rand's Phillipsburg, N. J., plant.

BULLETINS

Cycloidal Rotary Pumps. Roots-Connersville Blower Corp., Connersville, Ind. Bulletin 60-B-10. Pp. 4.

Aluminum Protective Paint. Quigley Company, New York. Bulletin. Triple-A No. 44 black anti-corrosive vehicle for aluminum. Pp. 6.

Flotation Index. Great Western Electro-Chemical Co., San Francisco. Bibliography of articles. Pp. 35.

Unit Flotation Cell. Denver Equipment Co., Denver, Colo. Bulletin 3421. Pp. 4. Also a reprint of articles (*E. & M.J.*, November, 1934) on the metallurgical practice of McIntyre Porcupine Mines, Ltd., describing the use of this unit cell in the company's mill.

Pulverizing. Raymond Bros. Impact Pulverizer Co., Chicago. Raymond Review for 1933. Pp. 14.

Torque Ring Couplings. John Waldron Corp., New Brunswick, N. J. Bulletin 48. Pp. 4.

Underground Conveyors. Demag, Duisburg, Germany, *Demag News,* January, 1934. Steel linked-plate conveyors. Pp. 7.

Rotary Granulator. Edgar Allen & Co., Ltd., Sheffield, England. All-steel K-B unit for producing cubical chippings. Pp. 32. Also a separate alphabetical guide to the company's products.

Air and Gas Compressors. Ingersoll-Rand Co., New York. Type XVG gas-engine-driven units. Pp. 24.

Texsteel Sheaves. Allis-Chalmers Manufacturing Co., Milwaukee, Wis. Pp. 4.

Centrifugal Pumps. Worthington Pump & Machinery Corp., Harrison, N. J. Type UB two-stage volute units. Pp. 4.

Power Transmission. Mechanical Power Engineering Associates, 684 St. Marks Ave., Brooklyn. Brochure giving a practical analysis of some fundamentals of industrial power transmission. Pp. 39.

Small Oil Circuit Breakers. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Catalog 33-200.

Electric Power and Lighting Plants. Harnichfeger Corp., Milwaukee, Wis. Bulletin EP1.

Ball Granulators. Allis-Chalmers Manufacturing Co., Milwaukee, Wis., Bulletin 1813-E. Pp. 28.

Electric Tugger Hoists. Ingersoll-Rand Co., New York. Catalog 1860-B. Single- and double-drum types. Pp. 38.

Daily and Average Monthly Prices of Metals

February, 1934

United States Market

Feb.	Electrolytic Copper Domestic	Electrolytic Copper Export	Straits Tin New York	Lead New York	Lead St. Louis	Zinc St. Louis
1	7.775	7.850	51.075	4.00	3.90	4.300
2	7.775	7.800	50.050	4.00	3.90	4.300
3	7.775	7.775	50.975	4.00	3.90	4.300@4.350
5	7.825	7.850	50.775	4.00	3.90	4.350@4.375
6	7.775	7.900	51.050	4.00	3.90	4.350@4.400
7	7.775	7.925	51.375	4.00	3.90	4.400
8	7.775	7.925	51.350	4.00	3.90	4.400
9	7.775	7.900	51.500	4.00	3.90	4.400
10	7.775	7.865	51.575	4.00	3.90	4.400
12	—Holiday—	7.850	—Holiday—			
13	7.775	7.875	51.600	4.00	3.90	4.400
14	7.775	7.775	51.550	4.00	3.90	4.400
15	7.775	7.725	51.625	4.00	3.90	4.400
16	7.775	7.775	52.050	4.00	3.90	4.400
17	7.775	7.825	52.100	4.00	3.90	4.400
19	7.775	7.800	52.600	4.00	3.90	4.400
20	7.775	7.850	51.900	4.00	3.90	4.400
21	7.775	7.850	52.400	4.00	3.90	4.400
22	—Holiday—	7.910	—Holiday—			
23	7.775	7.890	52.375	4.00	3.90	4.400
24	7.775	7.880	52.350	4.00	3.90	4.400
26	7.775	7.825	52.275	4.00	3.90	4.400
27	7.775	7.815	52.100	4.00	3.90	4.395
28	7.775	7.825	52.050	4.00	3.90	4.400
Av. for month	7.777	7.844	51.668	4.00	3.90	4.384
			Averages for Week			
7	7.783	7.850	50.883	4.00	3.90	4.344
14	7.775	7.865	51.515	4.00	3.90	4.400
21	7.775	7.804	52.113	4.00	3.90	4.400
28	7.775	7.858	52.230	4.00	3.90	4.399
			Calendar Week Averages			
3	7.796	7.867	50.904	4.00	3.90	4.296
10	7.783	7.894	51.271	4.00	3.90	4.390
17	7.775	7.804	51.785	4.00	3.90	4.400
24	7.775	7.863	52.325	4.00	3.90	4.400

Silver, Gold, and Sterling Exchange New York and London

Feb.	Sterling Exchange "Checks"	Sterling Exchange "90-Day Demand"	Silver (a) New York	Silver London	Gold London	(b) United States
1	4.98000	5.00250	43.6250	19.4375	135s6 d	$35.00
2	4.91500	4.92500	43.3750	19.2500	139s6 d	35.00
3	4.93000	4.94500	44.1250	19.9375	138s3 d	35.00
5	4.93250	4.94750	44.0000	19.6250	140s	35.00
6	4.96500	4.98000	44.1250	19.5625	139s3 d	35.00
7	4.99500	5.00500	44.5000	19.6875	136s6 d	35.00
8	5.01000	5.02500	44.5000	19.7500	136s9 d	35.00
9	5.01250	5.02250	44.7500	19.8125	137s4 d	35.00
10	5.02000	5.03000	44.5000	19.6875	137s1 d	35.00
12	—Holiday—			19.8750	137s2 d	35.00
13	5.03000	5.03500	44.7500	19.9375	136s11d	35.00
14	5.03000	5.03500	45.1250	20.2500	137s5 d	35.00
15	5.04250	5.05000	45.3750	20.1875	137s5 d	35.00
16	5.08500	5.09500	46.0000	20.3125	136s4 d	35.00
17	5.09750	5.10750	46.2500	20.3750	135s10d	35.00
19	5.13500	5.14000	46.7500	20.5000	134s9 d	35.00
20	5.06500	5.07000	46.0000	20.2500	135s9 d	35.00
21	5.07000	5.07500	46.3750	20.3750	136s5 d	35.00
22	—Holiday—			20.5000	136s1 d	35.00
23	5.07250	5.07500	46.6250	20.6250	136s5½d	35.00
24	5.07500	5.07750	46.3750	20.5625	136s6 d	35.00
26	5.08250	5.08500	45.8750	20.3750	136s5 d	35.00
27	5.07000	5.07250	45.7500	20.1875	136s7 d	35.00
28	5.06375	5.06875	46.3750	20.6875	137s1 d	35.00
Av. for month	5.03085	.....	45.233	20.073	.....	35.00
			Averages for Week			
7	4.95292	.....	43.958	.....	.....	.....
14	5.02050	.....	44.725	.....	.....	.....
21	5.08250	.....	46.125	.....	.....	.....
28	5.07275	.....	46.200	.....	.....	.....

Calendar week averages: New York Silver Feb. 3, 43.917; Feb. 10, 44.396; Feb. 17, 45.500; Feb. 24, 46.425.

(a) Silver not eligible for sale to U. S. Government.

(b) United States Treasury's gold price.

London Market

Feb.	Copper Standard Spot	Copper Standard 3M	Copper Electrolytic Bid	Tin Spot	Tin 3M	Lead Spot	Lead 3M	Zinc Spot	Zinc 3M
1	33.2500	33.3750	36.2500	226.5000	225.8750	11.3750	11.6875	14.6250	15.0000
2	33.5625	33.7500	36.7500	226.5000	226.0000	11.6250	11.9375	14.8125	15.1875
5	34.0000	34.1875	37.0000	227.3750	226.6250	11.7500	12.1250	14.8125	15.2500
6	34.0000	34.1875	36.5000	227.3750	226.6250	11.8125	12.1250	15.0625	15.4375
7	33.6250	33.8125	36.5000	226.7500	226.0000	11.6875	11.9375	14.8750	15.2500
8	33.8125	33.8750	36.7500	226.0000	225.6250	11.7500	12.0625	15.0625	15.3125
9	33.6250	33.7500	36.2500	226.3750	225.8750	11.7500	12.0625	15.0625	15.3750
12	33.2500	33.3750	36.2500	226.3750	225.8750	11.5000	11.8125	15.0000	15.3125
13	33.0000	33.1875	35.8750	225.7500	225.6250	11.4375	11.8125	14.8125	15.1250
14	32.8750	33.0000	35.7500	225.7500	225.5000	11.5625	11.8750	14.8125	15.1250
15	32.3750	32.5625	35.5000	225.5000	225.2500	11.4375	11.7500	14.8750	15.0625
16	32.5625	32.7500	35.5000	225.6250	225.6250	11.5000	11.8750	14.8125	15.0625
19	32.2500	32.4375	35.0000	226.1250	225.8750	11.6250	11.8750	14.6250	15.0000
20	32.6875	32.8750	36.0000	226.5000	226.2500	11.7500	12.0000	14.7500	15.0000
21	33.0000	33.1875	35.7500	227.5000	227.1250	11.7500	12.0000	14.8750	15.0625
22	33.1250	33.3125	36.0000	228.1250	227.8750	11.7500	12.0000	14.9375	15.2505
23	33.0000	33.1875	35.7500	228.1250	227.7500	11.7500	11.8750	14.8750	15.0520
26	32.5000	32.7500	35.5000	227.6250	227.2500	11.6250	11.7500	14.7500	14.8750
27	32.3750	32.5625	35.0000	227.1250	226.8750	11.6250	11.7500	14.6875	14.8125
28	32.5625	32.8125	35.5000	227.6250	227.1250	11.6250	11.9375	14.7500	14.9375
Av. for month	33.072	.....	35.969	226.731	.....	11.634	11.913	14.844	15.125

Correction — London zinc, three months, was £15.0625 on Jan. 30, 1934, and not £15.125 as previously noted. This changes the January average for three months zinc, London, to £14.943.

The United States quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices of domestic class are in cents per pound.

Copper, lead and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted as 0.35c. per pound above St. Louis, this being the freight differential. Contract prices for High-Grade zinc delivered in the East and Middle West usually command a pre-

Silver and Sterling Exchange

	New York		London Spot		Sterling Exchange	
	1933	1934	1933	1934	1933	1934
January	25.400	44.188	16.883	19.382	336.060	504.644
February	26.074	45.233	16.885	20.073	342.114	503.085
March	27.928		17.588		343.138	
April	30.730		18.440		357.565	
May	34.072		19.046		393.106	
June	35.663		19.078		413.216	
July	37.630		18.341		464.760	
August	36.074		17.877		449.944	
September	38.440		18.272		466.240	
October	38.190		18.221		466.380	
November	42.974		18.428		514.573	
December	43.550		18.674		511.260	
Year	34.727		18.144		421.530	

New York quotations, cents per ounce troy, 999 fine. London, pence per ounce, sterling silver, 925 fine. Sterling exchange in cents.

Copper

	F.O.B. Refinery			London Spot			
	Electrolytic			Standard		Electrolytic	
	Domestic		Export				
	1933	1934	1934	1933	1934	1933	1934
January	4.775	7.890	7.831	28.557	32.560	33.244	35.614
February	4.775	7.777	7.844	28.481	33.072	32.556	35.969
March	5.011			28.179		32.370	
April	5.395			29.576		33.681	
May	6.698			34.071		38.163	
June	7.773			36.759		41.000	
July	8.635			37.917		41.524	
August	8.768			36.071		40.227	
September	8.753			35.122		38.339	
October	7.950			33.656		36.977	
November	7.881			30.588		33.898	
December	7.885			31.306		34.329	
Year	7.025			32.524		36.359	

New York quotations, cents per pound. London, pounds sterling per long ton.

Lead

	New York		St. Louis		London			
	1933	1934	1933	1934	1933 Spot	1933 3 Mos.	1934 Spot	1934 3 Mos.
January	3.000	4.000	2.875	3.900	10.458	10.833	11.304	11.517
February	3.000	4.000	2.875	3.900	10.431	10.719	11.634	11.913
March	3.146		3.021		10.609	10.821		
April	3.260		3.135		10.872	11.122		
May	3.654		3.525		12.095	12.372		
June	4.173		4.023		13.280	13.571		
July	4.452		4.303		13.411	13.613		
August	4.500		4.350		12.182	12.457		
September	4.500		4.350		11.932	12.229		
October	4.313		4.176		11.804	12.102		
November	4.288		4.146		11.537	11.778		
December	4.141		4.042		11.431	11.658		
Year	3.869		3.735		11.670	11.940		

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Tin

	New York		London	
	1933	1934	1933	1934
	Straits		Standard, Spot	
January	22.692	51.891	145.708	226.631
February	23.500	51.668	148.544	226.731
March	24.221		149.120	
April	27.136		157.944	
May	36.051		186.207	
June	44.097		219.964	
July	46.356		216.673	
August	44.794		215.210	
September	46.665		216.893	
October	47.858		223.455	
November	53.011		226.722	
December	52.936		227.678	
Year	39.110		194.510	

New York quotations, cents per pound. London, pounds sterling per long ton.

Zinc

	St. Louis		London			
	1933	1934	1933 Spot	1933 3 Mos.	1934 Spot	1934 3 Mos
January	3.018	4.271	14.381	14.595	14.688	(a) 14.943
February	2.666	4.384	13.866	14.119	14.844	15.125
March	2.987		14.647	14.674		
April	3.298		14.951	15.208		
May	3.805		15.505	15.660		
June	4.348		16.988	16.774		
July	4.878		17.795	17.789		
August	4.916		16.869	17.031		
September	4.699		16.810	17.042		
October	4.748		16.310	16.599		
November	4.520		15.048	15.349		
December	4.461		14.826	15.059		
Year	4.029		15.666	15.825		

St. Louis quotations, cents per pound. London, pounds sterling per long ton. (a) Corrected.

Cadmium and Aluminum

	Cadmium		Aluminum	
	1933	1934	1933	1934
January	55.000	55.000	23.300	23.300
February	55.000	55.000	23.300	23.300
March	55.000		23.300	
April	55.000		23.300	
May	55.000		23.300	
June	55.000		23.300	
July	55.000		23.300	
August	55.000		23.300	
September	55.000		23.300	
October	55.000		23.300	
November	55.000		23.300	
December	55.000		23.300	
Year	55.000		23.300	

Aluminum in cents per pound, 99 per cent grade.
Cadmium, cents per pound.

Antimony, Quicksilver, and Platinum

	Antimony (a) New York		Quicksilver (b) New York		Platinum (c) New York	
	1933	1934	1933	1934	1933	1934
January	5.722	7.198	48.500	67.538	26.480	38.000
February	5.738	7.172	48.614	72.011	24.000	38.000
March	5.901		52.676		24.667	
April	5.876		54.580		26.800	
May	6.264		56.500		28.500	
June	6.500		60.038		30.000	
July	7.262		62.900		32.320	
August	6.986		63.500		33.000	
September	6.880		64.580		34.560	
October	6.843		66.500		36.000	
November	7.113		66.000		37.583	
December	7.250		66.330		38.000	
Year	6.528		59.227		30.993	

(a) Antimony quotations in cents per pound, for ordinary brands. (b) Quicksilver in dollars per flask of 76 lb. (c) Platinum in dollars per ounce troy.

Pig Iron

	Bessemer		Basic		No. 2 Foundry	
	1933	1934	1933	1934	1933	1934
January	14.50	18.00	14.00	17.00	14.50	17.50
February	14.50	18.00	14.00	17.00	14.50	17.50
March	14.50		14.00		14.50	
April	14.50		14.00		14.50	
May	15.42		14.42		14.92	
June	16.00		15.00		15.50	
July	16.50		15.50		16.00	
August	17.00		16.00		16.50	
September	18.00		17.00		17.50	
October	18.00		17.00		17.50	
November	18.00		17.00		17.50	
December	18.00		17.00		17.50	
Year	16.24		15.41		15.91	

Iron in dollars per long ton. F.o.b. Mahoning and Shenango Valley furnaces

mium of 1c. over Prime Western zinc.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

London prices for lead and zinc are the official prices for the first session of the London Metal Exchange; prices for copper and tin are the official closing buyers' prices. All are in pounds sterling per long ton (2,240 lb.).

New York silver quotations are as reported by Handy & Harman and are in cents per troy ounce of silver, 999 fine. London silver quotations are in pence per troy ounce of bar silver, 925 fine. Sterling prices represent noon market demand.